NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

HEADQUARTERS

SPACE TECHNOLOGY MISSION DIRECTORATE

300 E Street, SW

Washington, DC 20546-0001

UTILIZING PUBLIC - PRIVATE PARTNERSHIPS TO ADVANCE EMERGING SPACE TECHNOLOGY SYSTEM CAPABILITIES

SPACE TECHNOLOGY
ANNOUNCEMENT OF COLLABORATIVE OPPORTUNITY (ACO)

ANNOUNCEMENT NUMBER: NNH15ZOA001K

ACO Issued: May 21, 2015

NOI Due: July 1, 2015 (5:00 Eastern)

Proposals Due: July 30, 2015 (5:00 p.m. Eastern)

Catalog of Federal Domestic Assistance (CFDA) Number 43.012

OMB Approval Number 2700-0087

Offerors are reminded:

SEE SECTION 4.0 – PROPOSAL SUBMISSION INSTRUCTIONS. All proposals submitted via email or any means other than NSPIRES will not be accepted. Additionally, this section states:

"All proposals submitted in response to this solicitation must be submitted in electronic form by the **Authorized Organizational Representative (AOR)** at the proposing principal investigator's (PIs) organization who is authorized to make such a submission; electronic submission of the proposal by the AOR serves as the required original signature by an authorized official of the proposing organization. No hard copy of the proposal will be accepted.

The proposal submission process is complex and involves multiple steps to be carried out by all participants in the proposal. Therefore, offerors are strongly encouraged to familiarize themselves with the system and begin the submittal process early, well in advance of the deadline. While every effort is made to ensure the reliability and accessibility of submission systems and to provide a help center via e-mail and telephone, difficulties may arise at any point, including the user's own equipment. **Difficulty in registering or using NSPIRES is not a sufficient reason for NASA to consider a proposal submitted after the deadline."**

Summary of Key Information

Announcement Name: "Utilizing Public-Private Partnerships to Accelerate Space Technology System Capabilities", Space Technology Announcement of Collaborative Opportunity (ACO), hereafter called "ACO".

Goal/Intent: With this ACO, the National Aeronautics and Space Administration (NASA) continues to embrace public-private partnerships to achieve its strategic goals for expanding capabilities and opportunities in space. NASA's Space Technology Mission Directorate (STMD) is seeking potential partners through this ACO that focus on industry-developed space technologies that can enhance commercial space and benefit future NASA missions. NASA's investments in partnership with industry can accelerate the availability and reduce costs for the development and infusion of these emerging space system capabilities. Specifically, NASA is seeking to provide technical expertise, test facilities, hardware, and software to aid industry partners in maturing capabilities that can enable or enhance space vehicle systems and/or mature other closely related subsystems.

STMD is also releasing an Appendix to the NASA Research Announcement (NRA): Space Technology - Research, Development, Demonstration, and Infusion – 2015 (SpaceTech - REDDI) titled "Utilizing Public-Private Partnerships to Advance Tipping Point Technologies" that compliments the objectives of this ACO. Both solicitations embrace public-private partnerships to expand capabilities and opportunities in space. More specifically, the Tipping Point NRA Appendix focuses on partnerships between NASA and industry through the award of firm fixed priced contracts with a requirement for corporate/customer contributions that deliver technologies and capabilities needed for future NASA, other government agency, and commercial missions. In the Appendix, NASA is seeking commercial space technologies that are at a "tipping point" in their development. The technology topics listed in these two solicitations when taken together form a subset of the total field of topics that were considered by STMD for public-private partnership efforts to support commercial space interests. In selecting these topics for this year's solicitations, STMD considered responses received from the Tipping Point Request for Information (RFI), other recently released RFIs, as well as existing investments within NASA's technology portfolio for commercial space applications. It is STMD's intent to provide similar Tipping Point NRA and ACO opportunities for public-private partnerships on an annual basis.

Eligibility: Proposed efforts to this ACO must be led by U.S. industry defined as for-profit businesses that are incorporated in the United States of America. NASA will not consider proposals that do not include a U.S. industry business as the lead proposer. All private sector entities must partner with a NASA Center. The offeror may propose additional teaming arrangements (e.g. academia, non-profit, Federally Funded Research and Development Centers (FFRDCs), NASA civil servants, JPL) to optimize the potential for rapid development and infusion of the space technology. **Note: Only 1 proposal per topic or subtopic per offeror is permitted. Proposals may NOT cross topics.**

NOTE: *FFRDCs; U.S. federal, state, and local government entities, including National Laboratories; and NASA Centers are **not** eligible to participate as the **lead responder** in proposals under this ACO.*

Key Dates:

Release Date:	May 21, 2015
Virtual Industry Forum	June 17, 2015 (Target)
Notices of Intent Due:	July 1, 2015
Proposals Due:	July 30, 2015
Selection Announcement:	September 2015 (Target)
Award Date:	December 2015 (Target)

Virtual Industry Forum: NASA will host a virtual industry forum that will address key aspects of this ACO. The date targeted for this forum is Wednesday June 17, 2015. The agenda for the virtual industry forum and all other related information and material will be posted on the following website: http://www.nasa.gov/feature/opportunities-to-foster-commercial-space-technologies. Offerors are encouraged to regularly refer to this website for updates and other information relative to this ACO. Only those questions received by close of business on June 5, 2015 will be addressed at the forum. Questions regarding this Appendix should be submitted to **HQ-STMD-EmergingCapabilitiesACO@nasaprs.com**.

Proposal Submission & Selection Process: Competitive proposals with independent peer review

Technology Readiness Level (TRL): TRL information per topic is available in Section 2.1 below. Refer to NPR 7123.1B for NASA Technology Readiness Level (TRL) descriptions. The TRL descriptions can found by following the link:
http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE&search_term=7123.1b

Award Details:

Award Type: Non-reimbursable Space Act Agreements (SAA)

Award Duration: Maximum period of performance is dependent on the proposal topic and is defined in the Table under Section 2.1.

Anticipated Number and Amount of Awards: NASA reserves the right to select for award multiple, one, or none of the proposals in response to this Announcement. NASA reserves the right to negotiate, with selected offerors, terms of the SAA. The overall anticipated amount of funding/Full-Time Equivalents (FTEs) per Center and the number of awards are outlined in Section 2.0 of this ACO. Awards under this Announcement are subject to the availability of funding.

Selection Official: Space Technology Mission Directorate (STMD) Associate Administrator

Questions and Comments: Questions and comments about anything pertaining to this ACO, including the Virtual Industry Forum, should be submitted via email to: **HQ-STMD-EmergingCapabilitiesACO@nasaprs.com**

NOTE: *Questions of a general nature will be added to the FAQs for this ACO. The FAQs will be located under "Other Documents" on the NSPIRES page associated with this ACO.*

Table of Contents

1.0 SOLICITED RESEARCH/TECHNOLOGY DESCRIPTION

1.1 Introduction/Overview

The National Aeronautics and Space Administration (NASA) continues to embrace public-private partnerships to achieve its strategic goals for expanding capabilities and opportunities in space. A key aspect of NASA's strategy is to stimulate the commercial space industry while leveraging those same commercial capabilities through public-private partnerships to deliver technologies and capabilities needed for future NASA, other government agency, and commercial missions. With the recent increase of U.S. private sector companies interested in space applications, NASA is seeking commercial space technologies that can significantly benefit from collaborative partnerships to accelerate their development and utilization. These technologies must have a substantial benefit to both the commercial and government sectors once the capability development project completes.

The entrepreneurial U.S. commercial space industry is rapidly evolving, including the development of new sub-orbital and orbital launch vehicles as well as the development of new spacecraft technologies and the business models to implement them. However, it is also clear that this emerging industry faces significant challenges. Developers of these new space technology capabilities could benefit from NASA's unique experience, expertise, and facilities, available from nearly 60 years of space exploration. NASA can accelerate the development of key systems by providing opportunities for collaboration for multiple emerging sectors of commercial interest.

NASA's investments in partnership with industry can accelerate the availability and reduce costs for the development and infusion of these emerging space system capabilities. NASA's Space Technology Mission Directorate (STMD) is seeking potential partners through this Announcement of Collaborative Opportunity (ACO) that focuses on industry-developed space technologies that can enhance commercial space and benefit future NASA missions. Specifically, NASA is seeking to provide technical expertise, test facilities, hardware, and software to aid industry partners in maturing capabilities that can enable or enhance space vehicle systems and/or mature other closely related subsystems.

This Announcement is seeking proposals for space technology development and demonstration projects executed through Space Act Agreements (SAAs) between private industry and proposed NASA Centers. NASA will assign the resulting SAA awards, as public-private partnership projects, to STMD Programs at the time of award. It is anticipated that projects awarded from this Announcement will be assigned to either the Flight Opportunities Program, Game Changing Development (GCD) Program, the Small Spacecraft Technology (SST) Program, or the Technology Demonstration Missions (TDM) Program. More information about the NASA Space Technology Mission Directorate and STMD Programs can be found at: http://www.nasa.gov/directorates/spacetech/about_us/index.html

1.2 Announcement Goals and Objectives

NASA is soliciting proposals from all interested U.S. private sector enterprises that wish to enter into non-reimbursable Space Act Agreements (SAA) to collaborate for the accelerated development and testing of critical technologies for emerging space system capabilities. The purpose of these agreements is to advance commercial space-related efforts by facilitating access to NASA's extensive resources including facilities, technical expertise, hardware, and software. Technologies developed under these public-private partnerships should target rapid infusion infusion of the resulting capabilities into operational space systems.

NASA plans to use its other transactions authority within the National Aeronautics Space Act, 51 U.S.C. § 20113(e), to enter into non-reimbursable SAAs where each party bears the cost of its participation, and there is no exchange of funds between the parties. These SAAs will serve as an agency-level mechanism for NASA and its partners to agree to a series of mutually beneficial activities consistent with NASA's 2014 Strategic Plan. Proposed efforts must identify and specify alignment with NASA Strategic Goal 1: *Expand the frontiers of knowledge, capability, and opportunity in Space,* Objective 1.7: *Transform NASA missions and advance the Nation's capabilities by maturing crosscutting and innovative space technologies,* and National Space Policy Goal 1: *Energize competitive domestic industries.*

The SAAs are intended to facilitate a Partner's access to NASA's aeronautics and space resources including facilities, technical expertise, hardware, and software. **It is the responsibility of each proposer to develop the partnership with a NASA Center to coordinate roles, responsibilities, resources, and other activities to reach the technology development goals of the project. Offerors shall use the list of NASA Center Points of Contact provided as Attachment 7 to begin the partnership development process. The strength of such partnership arrangements will be evaluated as part of this Announcement.** Access to additional Government resources may be considered on a cost reimbursable basis and may require the negotiation of a separate Reimbursable Space Act Agreement with the appropriate NASA center or facility providing the requested resources.

1.3 Technology Topics

Under this ACO NASA will only consider proposals for partnerships in the following technology topic areas:

Topic 1: Suborbital Reusable and Small Satellite Launch Systems Development (see Attachment 1 for further details)

This topic focuses on the development and commercialization of small launch systems and related components. Vehicle classes include suborbital reusable launch systems and/or small satellite launchers. Small satellite launchers are defined here as delivering small satellites with a mass less than 180 kg to low earth orbit. Subtopics under this

topic area include air-launched systems, ground-launched systems, affordable auxiliary systems, and composite structures for small launch systems.

Responders should note that Topic 5, Small, Affordable, High Performance Liquid Propellant Rocket Engine Development, is intended to include development of primary propulsion for suborbital or small satellite launchers and the development of the upper stage propulsion for larger payload launch vehicles.

- **Subtopic 1 – Air Launch Systems** – Systems for air-based launchers to reduce the cost and complexity of launches by simplifying or eliminating infrastructure and other critical support elements.

- **Subtopic 2 – Ground Launch Systems** – Systems for ground-based launchers to reduce the cost and complexity of launches by simplifying or eliminating infrastructure and other critical support elements.

- **Subtopic 3 – Affordable Auxiliary Systems** – Systems to reduce the overall cost of a launch vehicle while improving the launch vehicle performance through advancements in subsystems for payload accommodation and release, pyrotechnics and separation systems, or avionics used for guidance, navigation, and control.

- **Subtopic 4 – Composite Structures for Small Launch Systems** - Structures to reduce vehicle cost and improve vehicle performance through the use of composite materials for primary and secondary vehicle structures.

- **Subtopic 5 – Small, Affordable, High Performance Liquid Propellant Rocket Engine Development** – See Topic 5

Topic 2: Wireless Power Transfer Development (see Attachment 2 for further details)

Onboard power generation by space assets such as spacecraft or planetary rovers continues to present difficult challenges, often entailing significant mass penalties, dramatically increasing the cost of missions, and in some cases obviating mission feasibility. Recent advances in high efficiency power transmission and reception components (Optical and RF), pointing and tracking, and heat exchangers will enable wireless power transfer as an alternative to onboard power generation. The capability holds the promise of radically transforming many types of commercial and NASA missions. Aside from generic support for space system development, NASA maintains a variety of useful capabilities including microwave test facilities and RF, optical, laser, and power system design/analysis to leverage for public-private partnerships. NASA is interested in supporting industrial partners in furthering their wireless power transfer technology and system developments efforts by providing technical expertise and access to these test facilities.

Topic 3: TPS Materials and Systems Development (see Attachment 3 for further details)

One of the most critical components of an atmospheric entry system is the thermal protection system (TPS), which can substantially drive cost, reliability, launch/landed mass, and overall system performance. Unlike many other technical areas, TPS development shares limited commonality with terrestrial applications, and the design, analysis, and test infrastructure for these systems represents a significant capital investment for any organization. Thus, commercial space ventures often have less industrial knowledge and less capability to leverage for this essential space system capability. NASA continues to make significant investments in TPS design, analysis, and test capabilities and is in a strong position to partner with commercial interests to assist in their efforts. The agency operates a number of world-class aerothermal test facilities capable of exposing TPS materials and system components to a wide envelope of entry heating environments (heat fluxes, pressures, enthalpies, etc.). NASA also has advanced computational hypersonic aerothermodynamics modeling capabilities, material thermal response modeling capabilities, and extensive experience in TPS design and development approaches. NASA is interested in supporting industrial partners in furthering their TPS material and system developments by providing access to these unique test facilities and technical capabilities.

Topic 4: Green Propellant Thruster Technology Qualification (see Attachment 4 for further details)

Monopropellant propulsion systems, predominantly using hydrazine as the propellant, represent a critical component of many spacecraft for attitude control, station keeping, and apogee orbital transfer. A strong desire exists to replace hydrazine with non-toxic high performance green propellant blends in order to improve performance, simplify handling/transfer ground operations, and reduce cost. In view of this need, NASA is offering a variety of capabilities that could benefit private sector thruster development and qualification efforts and is well poised to provide assistance via public-private partnerships. For instance, NASA operates a number of world-class propulsion test facilities capable of supporting the development and evaluation of thruster systems and components. NASA also has extensive propulsion engineering and analysis expertise that could assist in thruster design, manufacturing, and characterization. NASA is interested in supporting industrial partners in furthering their green propellant thruster developments by providing technical expertise and access to test facilities.

Topic 5: Small, Affordable, High Performance Liquid Propellant Rocket Engine Development (see Attachment 5 for further details)

The limited availability of affordable, high-performance small (< 35,000 lbf, <155 kN thrust) liquid propellant rocket engines represents an impediment to a viable small satellite launch capability as well as affordable upper stages for larger payload launch vehicles. Multiple commercial space companies are vigorously exploring approaches to address these engine development problems based on new manufacturing technologies, the leveraging of commercial off the shelf (COTS) components, and the

use of novel propulsion system technologies and design approaches. Developing and sustaining the expertise and capabilities associated with the design, development, test, and evaluation (DDT&E) of propulsion systems requires a substantial commitment of resources. NASA maintains a variety of capabilities that could potentially benefit private sector development and qualification efforts through a public-private partnership. For instance, NASA operates a number of world-class propulsion test facilities capable of supporting the development and evaluation of propulsion systems and components. NASA has also recently developed in-house additive manufacturing capabilities applicable to a wide range of rocket engine components that, due to their complexity, impose enormous cost and schedule demands upon traditional rocket engine development programs. Additionally, NASA has extensive propulsion engineering and analysis expertise that could assist in resolving developmental issues in the design, manufacturing, and test of engines. NASA is interested in supporting industrial partners in furthering their small high performance liquid propellant rocket engine developments by providing technical expertise, and access to both additive manufacturing fabrication and rocket engine test facilities.

2.0 AWARD INFORMATION

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Award Type: Non-reimbursable Space Act Agreement(s)

Award Duration: Maximum period of performance is dependent on the proposal topic and is defined in the table under Section 2.1 below.

2.1 NASA Center Funding and Period of Performance Information

Topic	Entry TRL	Anticipated Number of Awards	STMD Resources Available to NASA Centers	Period of Performance
Topic 1: Suborbital Reusable and Small Satellite Launch Systems Development	at least 4	up to 5	up to $1M total per award and up to 2 FTE per award per year	up to 24 months
Topic 2: Wireless Power Transfer Development	at least 3	up to 2	up to $2M total per award and up to 2 FTE per award per year	up to 24 months
Topic 3: TPS Materials and Systems Development	at least 3	up to 2	up to $1M total per award and up to 2 FTE per award per year	up to 24 months

Topic 4: Green Propellant Thruster Technology Qualification	at least 3	up to 2	up to $1M total per award and up to 2 FTE per award per year	up to 24 months
Topic 5: Small, Affordable, High Performance Liquid Propellant Rocket Engine Development	at least 3	up to 2	up to $2M total per award and up to 4 FTE per award per year	up to 24 months

2.2 Availability of Funds for Awards

NASA does not intend to provide any funding to Participants under these SAAs. Participants are expected to secure all of the funding necessary to perform their obligations under these SAAs. NASA will allocate funding/FTEs to the partnering NASA Center(s) in accordance with table above in Section 2.1. The Government's obligation to enter into and continue performance of agreements is contingent upon the availability of appropriated funds.

2.3 Use and Disclosure of Research Resulting From Awards

As a Federal Agency, NASA requires prompt public disclosure of the results of its sponsored research to generate knowledge that benefits the Nation. Thus, it is NASA's intent to broadly share all knowledge developed under awards resulting from this solicitation. In certain instances STMD programs expect award recipients to publish their work in peer-reviewed, open literature publications to the greatest extent practical.

NASA recognizes that cases exist where data disclosures to the public cannot occur (e.g., export controlled data). Even in these cases, offerors are expected to publish data to the greatest extent possible (e.g., use normalized data or at least discuss new methodologies used with clean "test cases"). NASA also understands that offerors may have legitimate proprietary interests in the technology or hold intellectual property rights to data they have produced at their own expense. If results must include proprietary or restricted information, offerors and awardees should appropriately mark and segregate such information into separate attachments to restrict it from public dissemination. A publicly releasable version of the final report and other deliverables shall be otherwise complete and comprehensive.

2.4 Intellectual Property Resulting From Awards

Under this ACO, Participants will retain intellectual property rights to the maximum extent allowed by law and regulation. Specifically:

1. NASA will not obtain rights in a Participant's background intellectual property (data and inventions developed at private expense that existed or were made prior to, or outside of, the Participant's agreement with NASA).

2. For privileged or confidential technical data (engineering, software, etc.) first produced by a partner and provided to NASA, NASA will disclose and use such data only for U.S. Government purposes.

3. Generally, ownership rights follow inventorship. For any inventions made by Participants in performance of work awarded from this ACO, NASA will normally not obtain any rights to such inventions.

4. For any inventions made by NASA employees in performance of work awarded from this ACO, NASA will use reasonable efforts to grant the Participant a license (on terms and conditions to be later negotiated).

A Participant's proprietary data, both existing proprietary data and data arising from work conducted under this agreement that a Participant considers proprietary, shall be appropriately marked by the Participant and protected by NASA, consistent with law.

2.5 Cost-Sharing or Matching

Not required.

2.6 International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) Requirements

It is incumbent upon the offeror to assure the protection and nondisclosure of relevant technical data, including requirements of the Export Administration Regulations (EAR) and International Traffic in Arms Regulations (ITAR). U.S. offerors are required to know when hardware, software, or related materials and services, including technical data, are subject to U.S. export control laws, including the U.S. Export Administration Act, the Arms Export Control Act, and their associated regulations. It is incumbent upon the U.S. offeror to strictly comply with all U.S. export control laws, and when applicable, assume the responsibility for obtaining export licenses, or other export authority, as may be required.

Under U.S. law and regulations, spacecraft and their specifically designed, modified, or configured systems, components, and parts are generally considered "Defense Articles" on the United States Munitions List and are, therefore, subject to the provisions of the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120-130. It is the offeror's responsibility to determine whether any proposal information is subject to the provisions of ITAR, and to comply with the provisions of ITAR. Information about U.S. export regulations is available at http://www.pmddtc.state.gov/ and http://www.bis.doc.gov/.

2.7 Schedule

NASA will commence its Partnership with the Participant upon execution of the SAA, which is targeted for November/December 2015. The period of performance will be defined in each SAA.

2.8 Compliance with U.S. Laws, Regulations, and Policies

Proposals must comply with all applicable U.S. laws, regulations and policies, including but not limited to the following:

1. National Space Policy of the United States of America, June 2010
2. National Space Transportation Policy, November 2013
3. Commercial Space Act of 1998 (P.L. 105-303; 51 U.S.C. 50101 et seq.)
4. Commercial Space Launch Act of 1984 (51 U.S.C. 50901 et seq.)

2.9 Title and Rights in Personal Property

The objective of this ACO is to advance private sector development of revolutionary space system capabilities so that the emerging products or services are commercially available to government and non-government customers within approximately the next five years. In order to foster such development, NASA anticipates that title to all personal property acquired or developed by a Participant under awards resulting from this ACO will remain with the Participant.

2.10 Partnerships and Use of Government Resources

It is the responsibility of each proposer to develop the partnership with a NASA Center to coordinate roles, responsibilities, resources, and other activities to reach the technology development goals of the project. Offerors shall use the list of NASA Center Points of Contact is provided as Attachment 7 to begin the partnership development process. The strength of the offeror's partnership will be evaluated as part of this Announcement.

As described in Section 1 of this document, the purpose of the SAA awards resulting from this announcement is to advance commercial space-related capabilities by facilitating access to NASA's aeronautics and space resources including facilities, technical expertise, hardware, and software. NASA may consider access to additional Government resources on a cost reimbursable basis, however such requests will require the negotiation of a separate Reimbursable SAA with the appropriate NASA Center or facility providing the requested resources. For this ACO, STMD only solicits for non-reimbursable SAAs at the levels specified in Section 2.1. In responding to this Announcement, NASA encourages participants to identify and specify to the greatest extent possible the precise Government resources and support requested. To this end, Attachment 6, Appendix 1 provides a non-comprehensive list of potential partnership opportunities available from NASA.

While a non-government organization must lead any proposal to this ACO, these proposals essentially entail a joint industry – NASA effort, with the lead NASA Center in each case contributing to the technology development project. Proposal instructions relative to the partnership requirements are contained in Section 4.0.

3.0 ELIGIBILITY INFORMATION

All U.S. private sector entities, including non-profits, may propose under this ACO. NASA will not consider proposals that do not include a domestic entity as the lead proposer. All private sector entities must partner with a NASA Center. The offeror may propose additional teaming arrangements (e.g. academia, non-profit, Federally Funded Research and Development Centers (FFRDCs), NASA civil servants, JPL) to optimize the potential for rapid development and infusion of the space technology. **Note: Only 1 proposal per topic or subtopic per offeror is permitted.**

NOTE: *FFRDCs; U.S. federal, state, and local government entities, including National Laboratories; and NASA Centers are **not** eligible to participate as the **lead responder** in proposals under this ACO.*

3.1 Limitation on Number of Proposals per Organization

Only 1 proposal per topic or subtopic per offeror is permitted.

3.2 Foreign Participation

Foreign participation is strictly prohibited on this ACO.

3.3 China Funding Restriction

Proposals must not include bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no-exchange-of funds arrangement. Grant Information Circular 12-01A instructs NASA, when issuing new NASA Research Announcements, to add the “Assurance of Compliance – China Funding Restriction” to the current proposal requirements.

The FY 15 Omnibus Appropriations Act, Public Law 113-235 Section 532 states that:

(1) NASA is restricted from using funds appropriated in the Acts to enter into or fund any grant or cooperative agreement of any kind to participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level and at all sub-recipient levels, whether the bilateral involvement is funded or performed under a no exchange of funds arrangement.

(2) Definition: “China or Chinese-owned Company” means the People’s Republic of China, any company owned by the People’s Republic of China, or any company incorporated under the laws of the People’s Republic of China.

(3) The restrictions in the Acts do not apply to commercial items of supply needed to perform a grant or cooperative agreement.

(4) By submission of its proposal, the proposer represents that the proposer is not China or a Chinese-owned company, and that the proposer will not participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level or at any sub-recipient level, whether the bilateral involvement is funded or performed under a no-exchange of funds arrangement.

NASA anticipates this restriction will be contained in future appropriation acts. Active Procurement Information Circular (PIC) 12-01A instructs Contracting Officers to add certification NFS 1852.225-72 entitled “Restriction on Funding Activity with China – Representation” as well as NFS clause 1852.225-71 entitled “Restriction on Funding Activity with China” in all contract awards.”

4.0. PROPOSAL SUBMISSION INFORMATION

A. **General**: NASA will not issue nor accept paper copies of this Announcement or proposals. NASA provides no funding for reimbursement of proposal development costs. Proposals submitted in response to this ACO will not be returned. It is the policy of NASA to treat all proposals as sensitive competitive information and to disclose the contents only for NASA purposes

B. **NSPIRES Registration Instructions**: Prospective responders shall submit proposals online, electronically, via the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) [**http://nspires.nasaprs.com**]. Information on how to access and submit proposals via NSPIRES can be found at the NSPIRES FAQ page [**https://nspires.nasaprs.com/external/faq.do - prop5**]. Every organization, including partner organizations (Co-I organizations, educational institutions, industry, not-for-profit institutions, and other U.S. Government agencies) that are part of the proposal team in response to this solicitation, must also be registered in NSPIRES. Details of the multi-step registration process, which takes about 3 business days (or up to four weeks if all steps are not completed in a timely manner) to register a new institution, are described in the Applicant User Guide.

   Registration in NSPIRES cannot be accomplished until each applicable institution obtains a Data Universal Number (DUNS) and registers in the System for Award Management (SAM).

   The proposal that is uploaded into NSPIRES must be Portable Document Format (PDF) file. Sections are to be consistent with the table listed in paragraph E below. The electronic proposal must be submitted by the Authorized

Organization Representative (AOR) at the proposing principal investigator's (PIs) organization who is authorized to make such a submission; electronic submission of the proposal by the AOR serves as the required original signature by an authorized official of the proposing organization. No hard copy of the proposal will be accepted. Proposals submitted via email or any means other than NSPIRES will not be accepted.

Each individual team member (e.g., PI, co-investigators, collaborators), including all personnel named on the proposal's electronic cover page, must be individually registered and affiliated with their organization in NSPIRES. Such individuals must perform the registration themselves; no one may register a second party, not even the PI of the proposal on which that person is committed to participate.

Each individual team member (e.g., PI, co-investigators, collaborators), including all personnel named on the proposal's electronic cover page, must specify an organizational affiliation. The organizational affiliation specified on the cover page must be the organization through which the team member would work and receive funding while participating in the proposed effort. If the individual has multiple affiliations, then this organization may be different from the individual's primary employer or preferred mailing address. Team members are asked to ensure that their contact information in NSPIRES is up-to-date. Changes can be made using the "Account Management" link on the "NSPIRES Options" page.

Submission of proposals requires action by both the PI and the AOR. First, the PI must complete all required electronic forms, and upload the required PDF file(s). Second, the AOR must submit the electronic proposal on behalf of the PI. Coordination between the PI and his/her AOR on the final editing and submission of the proposal materials is facilitated through their respective accounts in NSPIRES. Note that if one individual is acting in both the PI and AOR roles, he/she must ensure that all steps in the process are taken, including submitting the proposal from the organization.

Offerors should be sure to allow adequate time for coordination between the PI and AOR. Depending on the organization and its internal review process, this can take several days. The PIs are encouraged to begin this coordination at the outset of the proposal preparation.

The proposal submission process is complex and involves multiple steps to be carried out by all participants in the proposal. Therefore, offerors are strongly encouraged to familiarize themselves with the system and begin the submittal process early, well in advance of the deadline. While every effort is made to ensure the reliability and accessibility of submission systems and to provide a help center via e-mail and telephone, difficulties may arise at any point, including the user's own equipment. **Difficulty in registering or using NSPIRES is not a sufficient reason for NASA to consider a proposal submitted after the deadline.**

C. **Notice of Intent (NOI) to Propose**: is requested, but not required. The information contained in an NOI is used to expedite the proposal review activities and is, therefore, of value to both NASA and the offeror. Material in an NOI will be protected to the extent allowed by law and will be treated as confidential, nonbinding for the proposer, and will be used for NASA planning purposes only. An NOI is submitted electronically by entering the requested information at: http://nspires.nasaprs.com/. Note that NOIs may be submitted within NSPIRES directly by the PI; no action by an organization's AOR is required to submit an NOI. Within NSPIRES, space is provided for the PI to provide the following NOI information:

1. A full title of the anticipated proposal (which should not exceed 254 characters).
2. A brief description of the primary Technology Topics and objective(s) of the anticipated technology development.
3. The name of the proposal lead. Proposal lead, must have previously accessed and registered in NSPIRES.

D. **Quad Chart**: Provide a single 8.5 x 11 page summary chart which will be used to represent your proposal during the review process. This required summary chart does not count against the 20-page limit. Please closely follow the template provided at: http://www.nasa.gov/feature/opportunities-to-foster-commercial-space-technologies, and include the following components:

- Upper Left Quadrant: **Company Overview** - Title, company name and address, total number of company employees, brief company description, and teaming partners
- Lower Left Quadrant: **Technology Overview** - Technology overview to include: brief technology description, key required development, starting TRL, ending TRL, and short description of TRL basis
- Upper Right Quadrant: **Project Overview** - Project approach description to include: price, schedule, and major milestones
- Lower Right Quadrant: **Commercialization Overview** - Brief summary of commercialization strategy to include an estimate of the market value of the matured product/technology, intended commercial application, and NASA application
- Centered Across Four Quadrants: Technology image (size may be varied to best illustrate/explain)

The chart is intended to provide a quick sense of the proposed effort and should stand alone (i.e., not require the full proposal to be understood). It should not include any proprietary or sensitive data as NASA may make it available to the public after awards are announced.

E. **International Space Station (ISS) Research, Development, and Demonstration Opportunities:** The ISS provides proposers with a national laboratory resource with unique environments for the development of space

technologies. Although ISS utilization is not required, if the offeror proposes to use ISS, the following guidance is provided. The ISS program provides transportation to the ISS and standard experiment integration activities free of charge to approved, sponsored technology development investigations. For submissions proposing to utilize the ISS or its commercial launch assets please contact the ISS Research Integration Office to obtain a letter of feasibility. For STMD, Advanced Exploration Systems (AES), or general engineering research, development, or demonstration proposals, the point of contact is:

Dr. George Nelson: Manager, ISS Technology Demonstration Office, 281.244.8514, george.nelson-1@nasa.gov

F. The Proposal shall include the following, in the order listed:

	Proposal Section	Maximum Page Length
1.	**Table of Contents**	**1**
2.	**Technical and Management Section**	**up to 20**
3.	**Financial Plan Supporting the Proposed Development**	**as needed**
4.	**NASA Statement of Commitment**	**see below**

A page is defined as one side of a sheet, 8 1/2" x 11", with at least one inch margins on all sides, using not smaller than 12 point type, with the exception of tables and figures, which may use 8 point type. Foldouts count as an equivalent number of 8 1/2" x 11" pages. Pages in excess of the page limits for each section will not be evaluated.

Proposal Content details and instructions can be found in the Technology Topic Attachment. Respondents must provide enough detail in the proposal for NASA to make informed assessments against the specified evaluation criteria, also included in the Technology Topic Attachment.

1. Table of Contents:

Offerors should include a one-page Table of Contents that provides a guide to the organization and contents of the proposal. This item may also incorporate customized formats of the offeror's own choosing, e.g., identification of the submitting organization through use of letterhead stationery, project logos, etc.

2. Technical and Management Section:

Relevance to Solicitation Objectives:

A. Alignment: Define the technology underpinning the endeavor and its overall benefits. Describe the technology advancement for a mission capability, as opposed to an engineering effort or an open-ended research topic. Describe how the proposed effort is aligned with the goals and objectives in the solicited topic. Describe how the proposed technology development timeline aligns with the need date for future missions and applications.

B. Comparison to State-of-the-Art (SOA): Define the current state of the art and provide quantitative rationale how the proposed effort offers a revolutionary, disruptive, or transformational space technology that significantly improves performance over the current SOA.

C. Commercialization Plan: Provide a Commercialization Plan that includes a discussion of the commercial market for the capability or technology. Provide a viable business case to develop and commercialize the technology.

D. Infusion Potential: Provide documentation that potential end users of the technology (infusion customers, not technology developers) acknowledge the potential benefits of the technology and advocate for the investment in the technology. Demonstrate that there is a clear "receiving organization" that will benefit from the technology development. Provide clear evidence of NASA mission infusion and/or commercial sector application.

E. Value Proposition: Value proposition here is defined as the potential benefits of maturing the technology vs. the cost to mature the technology. Provide an assessment of the value proposition offered by comparing the relative proposed NASA resources versus the projected benefits or improvements in performance over the SOA. Demonstrate that a modest NASA investment of expertise and/or facilities will advance the desired technology compared to the existing investments in this technical area by other external organizations.

Technical Approach:

A. Technology Development Plan: Provide a technology development work plan including the scope of work performed by the NASA partner that includes a discussion of: the technical approach to accomplish the objectives of the effort within the proposed time period; the capability of proposed facilities, laboratory space, fabrication methods, equipment, and test techniques to accomplish the work; and the major technical challenges and risks and feasible mitigation strategies. The work performed by the NASA partner shall be consistent with the Statement of Commitment defined Proposal Section 4 below.

B. Qualifications and Capabilities: Describe the qualifications and capabilities of the project lead and team members including the skill, expertise, and experience needed to successfully execute the proposed technical approach. As detailed in Proposal Section 4 – NASA Statement of Commitment, describe the partnership with NASA, including the roles and responsibilities of each party. Describe the NASA resources requested compared to the overall resources required to

complete the effort and the availability of those resources. Describe the staffing of NASA and other prospective partners necessary to advance the technology.

C. TRL Assessment: Identify and substantiate that the entry TRL is appropriate for this solicitation and provide compelling rationale demonstrating that the proposed technical approach will achieve the TRL advancement specified in this Announcement.

D. Schedule: Provide a detailed schedule to include phasing of the work, clarity of the major milestones including measurable metrics, clearly articulated milestones, and adequate schedule margin. Provide the scheduled dates or time periods that the proposed effort would utilize specifically identified NASA in-house capabilities, such as facilities, equipment, or laboratories.

3. Financial Plan Supporting the Proposed Development:

Provide a financial plan including all costs to complete the technology development. Although NASA may provide resources at no cost to the selected offerors, include such costs in the financial plan, in order to identify the full cost of project. The plan shall include a discussion of the proposers level of financial solvency and the ability to stay solvent for the duration of the partnership; the potential benefits of the capability versus the cost to mature the capability; revenue and cost streams; and the level of commitment from financing and revenue sources.

4. NASA Statement of Commitment

A NASA Statement of commitment is required from the Center that will participate as a partner in the technology development and must be signed by a Center official with the authority to commit the resources. The statement shall include all of the required resources proposed from the Center acknowledging that the facility or resource is available for the proposed use during the proposed period. The definitions, specifications and descriptions of such government resources utilized in execution of awards shall include, but not limited to:

- **NASA expertise:** The number of personnel, the length and percent time for the personnel, the specific expertise of the personnel, and the tasks performed by the personnel.
- **NASA Facility, Building, or Lab Utilization:** A listing of the specific NASA test facilities or on site resources, the length of time in each facility or resources, the test setup details for each test, the approximate dates to perform the tests, and an accounting of the NASA and offeror personnel and materials needed to perform the test.
- **Use of NASA Software, Hardware, or Equipment:** A listing of the specific NASA equipment, software, and/or hardware, the length of time to use the resource, the details for the utilization of each resource, the approximate dates the utilization will occur, and an accounting of the NASA and offeror personnel and materials needed to perform the utilization.

5.0 PROPOSAL REVIEW INFORMATION

Compliance Check

All proposals will be screened to evaluate whether they comply with the Eligibility Information (Section 3.0) and Proposal Submission Information (Section 4.0) of this Announcement. Proposals that do not comply may be declared noncompliant and rejected without further review.

Evaluation Process

A Participant Evaluation Panel will evaluate proposals deemed compliant according to the evaluation criteria described in Section 5.0. NASA may request clarification of a specific point or points in a proposal. Such a request and the Respondent's response shall be in writing.

After evaluating each proposal, NASA will compare the results as part of a tradeoff analysis. The purpose of this tradeoff analysis is to select one or more approaches that best meet STMD Topic objectives, as described in each associated Attachment (1-4).

NASA may select a partner(s) based on initial proposal submissions. Therefore, Respondents should submit their best proposal in response to this Announcement. At its discretion, NASA may enter into due diligence with those companies whose proposals were most favorably evaluated. Due diligence may involve questions about the business, technical, and financial aspects of the proposals, requirements for NASA involvement, and any exceptions made to the draft SAA. If due diligence is conducted, proposers will be provided the opportunity to submit proposal updates.

Selection and Award

After completing the evaluation process defined above, NASA will present the results of the proposal evaluation to the Selection Official. The Selection Official will compare the proposals against one another and select a portfolio of one or more offerors whose proposals: are rated most highly based on the evaluation criteria contained in this Announcement, best provide a programmatic balance of content, best meet NASA strategic goals, and fit within NASA's available resources.

Upon selection, NASA will enter into negotiation with each selected participant on the proposed SAA. NASA reserves the right to select for execution all, some, or none of the proposals it receives in response to this Announcement. The competitive process will conclude with execution of an SAA between NASA and the selected participant(s).

Contractor Support Personnel

The Government will use selected contractor support personnel to assist in providing technical and business expertise in the evaluation of proposals. All contractor involvement in the evaluation process will be bound by appropriate conflict of interest

provisions and non-disclosure agreements to protect proprietary and competition sensitive information.

By submitting a proposal under this Announcement, the participant is deemed to have consented to release of data in its proposal to these NASA contractors supporting evaluation of proposals.

Evaluation Criteria

The three evaluation criteria listed below: Relevance to Solicitation Objectives, Technical Approach, and Financial Plan Supporting the Proposed Development are essentially equal in importance.

Relevance to Solicitation Objectives:

Evaluation includes consideration of the following:

A. Alignment: The extent to which the proposed effort sufficiently defines the technology underpinning the endeavor and its overall benefits. The extent to which the proposal focuses on a technology advancement for a mission capability, as opposed to an engineering effort or an open-ended research topic. The extent to which the proposed effort is aligned with the goals and objectives in the solicited topic. The degree to which the proposed technology development timeline aligns with the need date for future missions and applications.

B. Comparison to State-of-the-Art (SOA): The extent to which the proposal adequately and accurately defines the SOA for comparison. The extent to which the proposed effort offers a revolutionary, disruptive, or transformational space technology that significantly improves performance over the current SOA.

C. Commercialization Plan: The overall merit, rationale, and feasibility of the proposed Commercialization Plan including the reliability of the commercial market for the capability or technology. The extent to which the proposal presents a viable business case to develop and commercialize the technology.

D. Infusion Potential: The degree to which potential end users of the technology (infusion customers, not technology developers) acknowledge the potential benefits of the technology and advocate for the investment in the technology. The extent to which there is a clear “receiving organization” that will benefit from the technology development. The extent to which the proposed effort provides clear evidence of NASA mission infusion and/or commercial application.

E. Value Proposition: Value proposition here is defined as the potential benefits of maturing the technology vs. the cost to mature the technology. The extent of the value proposition offered in the proposed effort as determined by examining the relative proposed NASA resources versus the projected benefits or improvements in performance over the SOA. The extent to which the proposal

convincingly demonstrates that a modest NASA investment of expertise and/or facilities will advance the desired technology compared to the existing investments in the area by other external organizations.

Technical Approach:

Evaluation includes consideration of the following:

A. Technology Development Plan: The extent to which the offeror proposes a convincing technology development work plan including the scope of work performed by the NASA Partner; the feasibility and soundness of the technical approach to accomplish the objectives of the effort within the proposed time period; the capability of proposed facilities, laboratory space, fabrication methods, hardware, software, equipment, and test techniques to accomplish the work; the extent to which major technical challenges and risks are identified and feasible mitigation strategies are proposed.

B. Qualifications and Capabilities: The extent to which the proposal demonstrates that the project lead and team members have the skill, expertise, and experience needed to successfully execute the proposed technical approach. The extent to which the partnership with NASA, including the roles and responsibilities of each party are clearly defined to successfully develop and commercialize the technology as defined in the Proposal Section 4 – NASA Statement of Commitment. The extent to which the proposed NASA contributions are realistic considering all resources required to complete the technology development and the availability of those resources. The extent to which the proposed staffing from the NASA partner and other proposed partners are well qualified and sufficiently experienced.

C. TRL Assessment: The extent to which the entry TRL is appropriate for this solicitation and the degree to which the proposed technical approach will achieve the TRL advancement specified in this Announcement.

D. Schedule: The realism of the schedule relative to the phasing of the work and the clarity of the major milestones including measurable metrics, clearly articulated milestones, and adequate schedule margin. The scheduled dates or time periods that the proposed effort would utilize specifically identified NASA in-house capabilities, such as facilities, equipment, or laboratories.

Financial Plan Supporting the Proposed Development:

The Government will evaluate the proposed financial plan for the total cost to complete the technology development inclusive of the costs of the NASA resources. The strength of the NASA partnership (e.g. the nature and magnitude of resources supplied by the NASA Center) will be considered in evaluating the Financial Plan. The Government will evaluate the offerors level of financial solvency and the ability to stay solvent for the

duration of the partnership; whether the potential benefits of the capability justify the cost to mature the capability; the realism of proposed revenue and cost streams; and the level of commitment from financing and revenue sources.

By submitting a proposal, the offeror acknowledges that the proposal is valid for no less than six (6) months from submission.

6.0 POINTS OF CONTACT FOR FURTHER INFORMATION

Questions and comments about this Announcement may be submitted via email to: HQ-STMD-EmergingCapabilitiesACO@nasaprs.com

NOTE: Questions of a general nature will be added to the FAQs for this Announcement. The FAQs will be located under “Other Documents” on the NSPIRES page associated with this Announcement.

7.0 LIST OF ATTACHMENTS

Attachment 1: Technology Topic 1

Attachment 2: Technology Topic 2

Attachment 3: Technology Topic 3

Attachment 4: Technology Topic 4

Attachment 5: Technology Topic 5

Attachment 6: Draft Space Act Agreement

Attachment 7: NASA Center Points of Contact

ATTACHMENT 1:

TECHNOLOGY TOPIC 1 – Suborbital Reusable and Small Satellite Launch Systems Development

1.1 Description of Topic

The goal of this topic is to accelerate the development and testing of promising technologies for suborbital reusable and small satellite launch systems, with the ultimate goal of enabling commercial services. Small satellite launchers are defined here as delivering small satellites with a mass less than 180 kg to low earth orbit. Concepts for suborbital launch or launch to low earth orbit of very small payloads, such as CubeSats, represent an underserved demand in the current launch vehicle market. The base CubeSat dimension is 10x10x10 cm, one “unit” or “1U”, with a mass of up to 1.5 kg. Larger 3U, 6U, and 12U form factors, with appropriately scaled masses, are commonplace, and represent a significant component of the current small satellite launch demand. While the market need to provide such small launch capabilities continues to grow, actually providing these services with launch vehicles that offer a closed business model has proved elusive. STMD does not seek to directly obtain small launch vehicle services through this solicitation. Instead this solicitation acknowledges an understanding that the successful entry of future small launch capabilities into the market will require the development of vehicle and support systems that dramatically improve the affordability of small launch. NASA also recognizes that multiple commercial endeavors are devoting significant resources to meet this challenge. Given NASA’s experience in many of the technical areas related to launch, this topic area focuses on identifying and supporting through public-private partnerships those areas that represent obstacles to achieving affordable small launch. These collaborations should fit into an overall technology maturation plan as a bridge between developmental testing and the provision of commercial space services.

The main topic is divided into four industry-identified high priority subtopics, outlined below: air launch support systems, ground launch support systems, affordable auxiliary systems, and composite structures for small launch systems. Additionally, the technology topic described in Attachment 5 is applicable to engine development for suborbital and small satellite launch vehicles, as well as more generally to propulsion for upper stage launch vehicles.

1.1.1 Subtopic 1: Air Launch Systems

Range infrastructure typically accounts for a significant component of the launch cost of small launch systems and represents a particular challenge for their market viability. Both subsonic and supersonic air launch systems have been proposed, or are in development, that offer to reduce the launch infrastructure and launch costs, while improving launch availability and boosting launch performance. Autonomous flight termination systems and space based range/communications approaches offer means to both simplify the launch approval process and launch operations while also reducing

launch mass. Often government range and communications equipment are required by air launch system designs; however, with clever design approaches, commercial systems in both low Earth orbit (LEO) and higher energy orbits may offer better communication options. Air launch systems could deploy from above, below, or from within a carrier aircraft; other variations include towed launch and in-flight refueling or in-flight subsonic propellant manufacture.

NASA has a long history of developing, testing, and conducting operations with air launch systems. Examples include the X-15 program, the Eclipse project, and the X-43. The agency can offer institutional experience and subject matter experts to help solve aerodynamic, logistic, separation dynamics, and over all vehicle concept of operations challenges for air launch systems. NASA routinely conducts flight test operations with unique vehicles in high-risk environments. NASA engineers and technicians have experience with flight test planning and operations, development and installation of flight test instrumentation, vehicle design and analysis, wind tunnel testing, and integration of complex flight systems. Additionally, the agency can provide access to restricted airspace and test assets including chase aircraft, long-range optics, and telemetry infrastructure.

The topic solicits public-private partnerships with NASA to help resolve challenges in areas of relevant technology development, systems design, vehicle design, development, and demonstration of air-launched systems. NASA assistance with operational launch or flight services are not included in this topic area and proposals to partner on strictly revenue generating flights will not be accepted.

The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- Expertise and/or support analysis in:
    - Atmospheric flight planning and operations
    - Unmanned aerial vehicle (UAV) autonomous systems development (including guidance, navigation, and control)
    - Flight vehicle systems integration (including flight critical software validation)
    - Trajectory simulation
    - Small- to full-scale UAV operations (including Restricted Airspace)
    - Range safety, including E_c calculations
    - Surveillance and recovery
- NASA test facilities utilization and support:
    - Aero-structural (thermal/structural) combined full-scale loads testing
    - Tracking and calibrated range facilities
    - Flight operations facilities (including control room facilities, hangars, maintenance, fabrication)
    - Hardware-in-loop engineering simulation

    - Aerodynamic wind tunnel facilities
    - Air-launch carrier vehicle and carried launch vehicle processing
    - Air-launch operations
    - Flight facilities to support large aircraft, including large runways
- Access to large areas of restricted airspace

Contributions from prospective partners may include but are not limited to:

- The concept of operations for the planned operational air launch system and anticipated flight profiles
- A concept of operations for the collaborative effort to test the air launch system or related subsystem
- Technical drawings and digital models (aerodynamic models, wiring diagrams, etc.) of the system being designed/evaluated
- Performance data and desired test/analysis points of the system being designed/evaluated (NASA can help develop a test or analysis plan from the concept of operations)
- List of desired test measurements and instrumentation
- Ground test articles or wind tunnel models that are appropriately sized for the desired facility and meet required safety and interface standards (NASA points of contact for the desired facility can help identify those requirements)
- Drawings and specifications for ground test articles
- Test article hardware and/or software, including vehicle subsystems or a completed flight article (as appropriate)
- For any ground test, wind tunnel test, or flight test (including access to restricted airspace) NASA will require relevant data to ensure safety of government assets, personnel, and the public during the testing

1.1.2 Subtopic 2: Ground Launch Systems

Clean-pad concepts can help improve the affordability and launch availability of proposed ground launched systems. Conceptually, clean pad designs can operate from a simple launch stool and/or concrete pad. Such designs typically eliminate required infrastructure elements and reduce overall maintenance and operations costs associated with launch systems. Examples of eliminated infrastructure elements in a clean-pad include water deluge systems (jets of water directed over the launch pad that also double as acoustic shock suppressors and flame deflectors), launch towers and/or erection systems, specialized cranes and transport systems, propellant loading equipment and carts, power supplies, communications equipment, permanent tank farms, and numerous fly-away umbilical connections. Moving to a clean-pad approach is particularly compelling for small satellite launch systems where the development and maintenance of additional infrastructure disproportionately adds to the overall costs.

Means to promptly refurbish the launch site for an upcoming launch, such as robust launch stand designs and/or rapidly replaceable ground launch elements, also hold significant interest. These ground launch elements typically endure exposure to hostile launch environments including thermal and structural loads, pyrotechnic shock, atmospheric overpressure, vibration, and acoustics. Means to eliminate fly-away

connections and simplify loading operations may include aft-mount umbilicals for power, communications, and propellant/pressurization systems. The majority of these operability-oriented ground technologies exist in some form.

Providing the capability to launch from varied locations by deploying and re-locating launch equipment holds extreme interest for suborbital and small satellite launch vehicle developers and operators. The approach dramatically improves launch flexibility and launch robustness. Allowing simple and prompt relocation to alternate launch sites would enable, with prudent site selection, access to virtually all inclinations and orbital planes. The ability to easily and rapidly relocate the launch site may also provide the ability to avoid inclement weather as well as natural and manmade disasters. Specialized deployment systems or payload support systems fall into this category.

NASA has extensive experience conducting launch operations and designing, operating, and maintaining ground launch infrastructure. The agency has been investigating systems and technologies associated with increasing launch responsiveness and reducing launch costs and infrastructure. Examples include deployable launch systems and portable multi-use propellant servicing systems. NASA can offer institutional experience and subject matter experts to help reduce the required launch infrastructure and improve operational availability for a ground-launched system. The agency can also provide access to facilities and equipment to conduct pathfinder or test launch operations.

The topic solicits public-private partnerships with NASA to help resolve challenges in areas of relevant technology development, system design, and demonstration of ground launch systems. NASA assistance with operational launch services are not included in this topic area and proposals to partner on strictly revenue generating launches will not be accepted.

The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- Expertise and/or support analysis in:
    - Cryogenic propellant handling and loading
    - Simulated propellant handling and loading
    - Ground support equipment design, development, test and evaluation
    - Flight hardware handling and transportation equipment
    - Launch vehicle propellant and gas system design and supply of consumables (cryogenics, pneumatics, hypergolic, hydraulics)
    - Command and control systems
    - Ground systems operations and maintenance
    - Automation of operations and maintenance, robotics, and software
    - Range safety analysis
- NASA test facilities utilization and support:

- Launch vehicle processing, payload processing, and related ground support equipment
- Integrated testing, servicing, launch, recovery, real-time mission monitoring (including data acquisition, mobile range, telemetry and tracking)
- Real-time anomaly resolution, communications and post-flight analyses
- Deployable launch system and universal propellant servicing system
- Sounding rocket launch pads
- Mobile launch systems

Contributions from prospective partners may include but are not limited to:

- The concept of operations for ground processing and launch of the operational system
- Concept of operations for the collaborative test effort
- Launch vehicle or launch vehicle pathfinder
- Vehicle interface documents including descriptions and requirements for mechanical, electrical, and propellant/fluid servicing interfaces
- Technical drawings and digital models (vehicle models, wiring diagrams, etc.)
- Properties and material safety data sheets for propellants, fluids, etc.
- Vehicle performance data and flight path
- Vehicle ground and launch limits
- Designs of ground test articles; test article hardware and/or software
- For any ground or launch operation, NASA will need relevant data to ensure safety of government assets, personnel, and the public during the testing

1.1.3 Subtopic 3: Affordable Auxiliary Systems

Miniaturization of avionics components including microprocessors, application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), Global Positioning System (GPS) receivers, software defined radios (SDRs), accelerometers, inertial measurement units (IMUs), cameras, and antennas have already revolutionized consumer electronics and are numerous in devices such as smartphones. These types of electronics are now successfully migrating into small satellite designs. Similar suites of miniaturized components offer significant potential to provide affordable low SWaP (size, weight, and power) avionics for suborbital and small satellite launch vehicles.

Pyrotechnic devices and classic launch vehicle separation systems typically impose harsh environments, require specialized handling and safety protocols, and carry size, mass, and cost penalties that pose significant challenges to suborbital and small satellite launch systems. Approaches to reduce mass and ameliorate induced environments while also reducing costs and improving reliability are therefore desired. Characterization of pyrotechnic shock effects on composite materials is needed. Miniaturized and lightweight actuators, valves, and control surfaces also hold high interest.

NASA has invested in low cost systems for use in small satellites, specifically leveraging advances in consumer electronics to field smaller, lighter weight, and lower power

systems. NASA can provide expertise in this area, including how to incorporate COTS products into vehicle designs and how to test those items for use in the spaceflight environment. The agency can also provide expertise and subject matter experts in avionics, pyrotechnic staging devices, and other flight systems. Where applicable, NASA can also transfer existing auxiliary system designs and hardware, for example, the Affordable Vehicle Avionics (AVA) system, which is a low cost, modular, guidance, navigation, and control system.

The topic solicits public-private partnerships with NASA to help resolve challenges in developing and fielding low cost vehicle subsystems. NASA assistance with operational launch or flight services are not included in this topic area and proposals to partner on strictly revenue generating operations will not be accepted.

The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- Expertise and/or support analysis in:
    - Onboard data acquisition, guidance, navigation, and telemetry
    - Payload interface installation and eject mechanism design
    - Flight controls
    - Hardware test and evaluation
    - GNC design and analysis
    - Instrument pointing control design
    - Avionics, instrumentation, & systems development
- NASA test facilities, hardware and software utilization, and support may include:
    - Environmental testing, including vacuum and thermal chambers, vibration stands and acoustic test cells
    - Government furnished GNC software and/or hardware from NASA activities such as the Affordable Vehicle Avionics (AVA) system

Contributions from prospective partners may include but are not limited to:

- The operational concept of operation for the system
- Launch vehicle or vehicle systems
- Interface control documents
- Vehicle guidance navigation and control laws
- Technical drawings and digital models (wiring diagrams, etc.)
- Vehicle loads and environments (shock, vibration, etc.)
- Vehicle performance data
- Hardware and / or software to be tested / evaluated
- For any ground or flight test, NASA will need relevant data to ensure safety of government assets, personnel, and the public during the testing

1.1.4 Subtopic 4: Composite Structures for Small Launch Systems

Because of their desirable structural properties (high specific strength and specific stiffness), composite materials are key candidates for primary and secondary structures, including fuel tanks and pressure vessels, on suborbital and small satellite launch vehicles. While the aviation industry generally understands composites and their characteristics, these materials face unique environmental operating conditions during the flight of suborbital and orbital launch systems and in some cases during reentry. These hazards can include extreme vibration and acoustic loading, extreme temperatures, extreme pressure changes, and electromagnetic effects. Understanding these environments and their effects on composite material performance is necessary to ensure operational safety. For reusable vehicles or subsystems, operators must have processes and procedures in place to properly inspect, maintain, and return composite hardware to flight condition.

A significant factor in the design of launch systems involves the operational environment and its effects on primary and secondary composite structures. NASA has substantial expertise and experience with full-scale testing of vehicle structures in relevant environments. Testing should evaluate effects of impact, lightning strike, temperature, ultraviolet radiation, corrosion, and humidity. Other important considerations in the use of composite structures in a space environment include the effects of outgassing on nearby electrical and optical components.

This subtopic solicits public-private partnerships between NASA and industry to develop and validate the use of composites for primary and secondary structures of suborbital and small satellite launch vehicles. Efforts to adopt composite structures for future launch systems can benefit from NASA expertise and the utilization of NASA facilities to assist in manufacturing and/or testing. NASA assistance with operational launches or flight services is not included in this topic area and proposals to partner on strictly revenue generating operations will not be accepted.

The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- Prototype manufacturing of a limited set of composite components
- Expertise to assist in the design of the launch system using composites
- Environmental and performance testing of composite components
- Evaluation of various techniques to inspect, maintain, and repair composite systems
- Evaluation of operational limitations and the development of inspection requirements for flight vehicles by subjecting composite vehicle prototypes to a typical flight profile
- Developing procedures for maintenance, repair, and replacement of composite components

- Nondestructive evaluation (NDE) and damage tolerance testing

Contributions from prospective partners may include but are not limited to:

- Materials for prototype composite structure fabrication
- The concept of operations and typical flight profile of the intended vehicle that would incorporate composite structures
- Technical drawings and performance data of the intended vehicle that would incorporate composite structures
- Composite material properties for material response model development
- Composite test coupons and/or composite hardware components or systems for use in environmental, structural performance and NDE testing
- Composite hardware components or systems for evaluation and the development of maintenance and repair techniques and procedures
- For any ground test, NASA will need relevant data to ensure safety of government assets, personnel, and the public during the testing

1.1.5 Subtopic 5: Small, Affordable, High Performance Liquid Propellant Rocket Engine Development

The topic described in Attachment 5 is applicable to main propulsion for suborbital and small satellite launch vehicles as well as upper stage vehicles for higher payload mass launch systems.

1.2 Partnership Coordination

Offerors are required to partner with NASA Centers for support. The Lead Center for each subtopic will coordinate the partnerships. Additional design, test, and analysis support can be coordinated with support Centers. NASA Center points of contacts can be found in Attachment 7.

The Lead and Supporting Centers and POCs are shown below for each of the subtopic areas:

- Subtopic 1 – Air Launched Systems

Lead Center: Armstrong Flight Research Center (AFRC)
Supporting Centers: Kennedy Space Center (KSC), Goddard Space Flight Center (GSFC)/Wallops Flight Facility, Langley Research Center (LaRC)

- Subtopic 2 – Ground Launched Systems

Lead Center: Goddard Space Flight Center (GSFC)/Wallops Flight Facility
Supporting Center: Kennedy Space Center (KSC)

- Subtopic 3 – Affordable Auxiliary Systems

Lead Center: Goddard Space Flight Center (GSFC)/Wallops Flight Facility
Supporting Centers: Marshall Space Flight Center (MSFC)/Michoud Assembly Facility (MAF), Jet Propulsion Laboratory (JPL)

- Subtopic 4 – Composite Structures for Small Launch Systems

Lead Center: Langley Research Center (LaRC)
Supporting Center: Marshall Space Flight Center (MSFC)/Michoud Assembly Facility (MAF)

1.3 Programmatic Considerations

There are no specific deviations from the main announcement details, except as noted below. Proposals should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0.

This Topic is not a solicitation for actual flight or launch services; it is for capability development collaboration. Potential responders are reminded that the goal of this topic is to accelerate the development and testing of promising technologies for suborbital reusable and small satellite orbital launch systems, with the ultimate goal of enabling commercial services. Particular emphasis should be given to the Commercialization Plan, SOA, and TRL Assessment to establish that the proposed collaboration will result in a viable commercial product or service. No awards made under this topic will be for flight services activities but rather for focused technology development and demonstration.

ATTACHMENT 2:

TECHNOLOGY TOPIC 2 – Wireless Power Transfer Development

2.1 Description of Topic

An enduring theme in space exploration is the difficulty of generating the required power at the point of use. Onboard power generation by space assets such as spacecraft or planetary rovers continues to present difficult challenges, often entailing significant mass penalties, dramatically increasing mission costs and in some cases obviating mission feasibility. For decades, NASA engineers have sought a means to separate the power generation capability from the end user, and in the process enable missions not otherwise possible. Researchers have investigated many techniques to wirelessly transmit and receive power over distances great and small, unfortunately such technology investigations have not yet translated into routine use in aerospace applications. Numerous terrestrial applications are now in operation or in further development, and commercial space applications are beginning to emerge.

An opportunity now exists to capitalize on recent developments in efficient power transmitter and receiver technologies to realize wireless power transfer for aerospace applications. Specific enabling technologies, among others, include high efficiency transmit systems (RF or Optical), pointing and tracking systems, heat exchangers capable of converting beamed energy to thermal energy, and monochromatic photovoltaic receivers.

NASA maintains a variety of useful capabilities to leverage for public-private partnerships on this topic, some gained through the Millimeter-Wave Thermal Launch System (MTLS) Project. NASA test facilities, including specialized microwave test facilities, antenna test ranges, and other optical/RF test laboratories and extensive experience in the design of RF, optical, laser, and power systems may also augment an industrial partner's wireless power transfer development.

This technology topic seeks NASA partnerships with industry to develop and validate the capability to wirelessly transfer power between assets. This topic includes applications such as:

- Terrestrial beamed power to a spacecraft for launch
- In-space power beaming between orbiting spacecraft (including from a spacecraft to an EVA suit)
- Power beaming from an in-space orbiting spacecraft to a planetary asset
- Power beaming between mobile assets on the surface of a planetary body

A public-private partnership with NASA would help mature Industry-led capabilities by leveraging NASA technical expertise and test facilities. NASA envisions that a team comprised of NASA civil servants and an industry partner would work together to design, develop, and test power transmission and receiver systems. The proposed

scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- Access to test facilities such as thermal vacuum chambers and other environmental test facilities, clean rooms for integration and test, antenna test ranges, and government-owned, contractor-operated test assets such as the High Performance Microwave (HPM) facility
- Access to or loan of high performance lasers, lenses, mirrors, or other optics components
- Access to or loan of test equipment such as optics benches, spectrum/network analyzers, waveform generators, power sources/supplies, etc.
- Access to manufacturing facilities for ceramics and other laser/optics components
- Design and analysis expertise including detailed power systems, optics, lasers, and telescope, and RF systems
- Systems engineering efforts associated with spacecraft integration and system design, e.g. thermal analysis, packaging, etc.
- Assistance in developing experiments and technology demonstration payloads for the International Space Station (ISS)
- Consultation on laser safety

Contributions from prospective partners may include but are not limited to:

- Test articles, development hardware, and related subsystems for test collaborations
- Resources required for the partner to help plan and witness any technology evaluation or tests including the partner's labor and travel
- The expected performance characteristics of the system or system component as they relate to potential applications of benefit to future NASA/OGA missions or missions in the commercial sector

2.2 Partnership Coordination

Offerors are required to partner with NASA Centers for support. The Lead Center coordinating all partnerships for this topic is NASA Ames Research Center (ARC). Additional design, test, and analysis support can be coordinated with Johnson Space Center (JSC)/ White Sands Test Facility (WSTF), Glenn Research Center (GRC)/Plum Brook Station, and Langley Research Center (LaRC). NASA Center points of contacts can be found in Attachment 7.

2.3 Programmatic Considerations

There are no specific deviations from the main announcement details. Proposals should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0.

ATTACHMENT 3:

TECHNOLOGY TOPIC 3 – TPS Materials and Systems Development

3.1 Description of Topic

The Entry, Descent, and Landing (EDL) phase of a mission represents a significant challenge for both NASA and commercial entry system developers. A critical component of almost every entry system is the thermal protection system (TPS), which can substantially drive cost, reliability, payload/landed mass, and overall system performance. Unlike many other technical areas, TPS development shares limited commonality with terrestrial applications, and the design, analysis, and test infrastructure for such systems represents a significant capital investment for any organization. Thus commercial space ventures often have less industrial knowledge and less capability to leverage for this essential space system capability. Ablative and reusable TPS materials with reduced areal densities, reduced production and/or integration costs, more robust or multifunctional performance, and higher reliability and reusability are of interest to NASA and emerging commercial entities. These systems are not only of interest in performing atmospheric entry from space but are also of interest in returning reusable launch vehicle stage elements to Earth.

NASA continues to make significant investments in TPS design, analysis, and test capabilities and is in a strong position to partner with commercial interests to assist in their efforts. The Agency operates a number of world-class aerothermal test facilities to support development and qualification of TPS materials. These facilities are capable of exposing TPS materials and system components to a wide envelope of operating environments (heat fluxes, pressures, enthalpies, etc.) experienced during atmospheric entry. Additionally, NASA has advanced computational hypersonic aerothermodynamics modeling capabilities as well as material thermal response modeling capabilities. NASA also has extensive experience in TPS design and development approaches.

NASA is interested in supporting industrial partners in furthering their TPS material and system developments by providing technical expertise and access to test facilities. The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners. The potential NASA contributions to a partnership with U.S. industry generally include:

- **Technical Expertise**: NASA personnel will work with the industry partner to support design, development, analysis, and testing of new material systems and system components.

- **Test Facilities**: NASA will provide access to world-class arc jet and aerothermal test facilities.

NASA-offered support may include but is not limited to:

- NASA personnel to assist in the further design and development of TPS materials or system components
- Aerothermal analysis of flight conditions and/or material thermal response
- Aerothermal analysis of test conditions and/or material thermal response
- Arc jet testing time at conditions of interest to the application
- Detailed designs for acceptable and existing material system test samples, model instrumentation, and model holders
- Labor resources necessary to execute the final assembly of the instrumented test models and perform the technology performance evaluations
- Resources required to operate the data acquisition system and to store the acquired data
- Access to the facility during preparation for, and execution of, the test program
- Post-test analysis and expert evaluation of the acquired data

Contributions from prospective partners may include but are not limited to:

- The expected performance characteristics of the TPS material or system component as they relate to potential applications of benefit to NASA's future missions or other missions in the overall U.S aerospace enterprise
- TPS material/system test models for arc jet evaluation, as well as the necessary instrumentation and model holders or the resources to obtain them
- Resources required for the partner to help plan and witness the technology evaluation including the partner's labor and travel

3.2 Partnership Coordination

Offerors are required to partner with NASA Centers for support. The Lead Center coordinating all partnerships for this topic is NASA Ames Research Center (ARC). Additional design, test, and analysis support can be coordinated with Johnson Space Center (JSC)/White Sands Test Facility (WSTF) and Langley Research Center (LaRC). NASA Center points of contacts can be found in Attachment 7.

3.3 Programmatic Considerations

There are no specific deviations from the main announcement details. Proposals should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0.

ATTACHMENT 4:

TECHNOLOGY TOPIC 4 – Green Propellant Thruster Technology Qualification

4.1 Description of Topic

Green propellant thrusters offer significant advantages over traditional hydrazine thrusters in terms of reduced toxicity and high density impulse performance. Despite these attractive features, particularly cost savings associated with reduced propellant loading hazards and elimination of Self Contained Atmospheric Protective Ensemble (SCAPE) suit operations, space mission acceptance and infusion is impeded by unretired technical risks and the need for space flight qualification. Thruster developmental efforts to date have focused primarily on the 1-50 N (0.2-10 lbf) thrust range. Developing thrusters that address the 1-22 N (0.2-5 lbf) range offers at least 80% market coverage of the current hydrazine thruster market. Green propellant technology developments have reached a moderate level of maturity for both ammonium dinitramide (ADN) and hydroxylammonium nitrate (HAN) based blends with an eye toward near term infusion. Other non-toxic monopropellant formulations can potentially offer similar advantages. Propulsion system trade studies have also indicated good upward scalability to the 220-440 N (50-100 lbf) thrust range yielding competitive advantages with respect to exploration mission applications.

In some cases, industry-led propulsion system developments utilizing either HAN or ADN have achieved or are near to achieving flight demonstration status. For example, the Green Propellant Infusion Mission (GPIM) will demonstrate the practical capabilities of a HAN blend known as AF-M315E. PRISMA, a Swedish technology development mission, demonstrated an ADN-based monopropellant called LMP-103S with 1 N thrusters. However, development beyond ground test units has only proceeded for one or two thruster sizes in the case of both HAN and ADN formulations. Additional flight thruster qualification is needed for green propellant technologies to gain acceptance for future space missions.

Despite the steady maturation of industry developed thrusters several technical concerns require further resolution to expand the capabilities and improve the reliability of available thrusters and allow the technology to achieve commercial viability. These concerns broadly encompass developmental issues touching on performance, material compatibility, scalability, and life. For example, additional efforts are needed to resolve uncertainties associated with incomplete combustion, catalyst heating requirements and washout, alternate non-catalytic ignition schemes, warm/cold starts, fabrication for system resilience against deep thermal cycles and gradients, material compatibility uncertainties for seals and tank bladders, and thermal stability. Thruster development efforts that address these technical concerns and accelerate space flight qualification are of high interest.

Given the level of technical maturity, the strong desire to reduce reliance on hydrazine, and NASA’s capabilities, the challenge of green propellant thruster technology offers an opportunity for facilitated development using a public-private partnership. NASA

operates a number of world-class propulsion test facilities capable of supporting the development and evaluation of thruster systems and components. NASA also has extensive propulsion engineering and analysis expertise that could assist in thruster design, manufacturing, and characterization. NASA is interested in supporting industrial partners in furthering their green propellant thruster developments by providing technical expertise and access to test facilities.

Proposals of interest would leverage corporate investment with publically provided test facilities, technical expertise, and other technical capabilities to productively address unresolved development concerns and advance the TRL of commercially available thrusters for accelerated mission acceptance and infusion. The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA-offered support may include but is not limited to:

- NASA personnel to assist in the further design, development, testing, and qualification of flight-like thruster systems
- Engineering assistance with analysis and technology development risk reduction efforts addressing design, manufacturing, performance, stability, thermal, material compatibility, scalability, and life concerns
- Engineering assistance with thruster qualification
- Thruster testing time at conditions of interest to space qualify a particular thruster design
- Assistance with sensors, diagnostics, instrumentation, and measurements for thruster characterization
- Labor resources necessary to execute the final assembly of the instrumented thrusters and perform the technology performance evaluations
- Resources required to operate the data acquisition system and to store the acquired data for a NASA test facility
- Post-test analysis and expert evaluation of the acquired data from a NASA test facility

Contributions from prospective partners may include but are not limited to:

- The expected performance characteristics of the thrusters as they relate to potential applications of benefit to NASA’s future missions or other missions in the overall U.S aerospace enterprise
- Thruster system/component hardware and propellants for performance evaluation and/or space flight mission utilization
- Resources required for the partner to help plan and witness the technology evaluation including the partner’s labor and travel

4.2 Partnership Coordination

Offerors are required to partner with NASA Centers for support. The Lead Center coordinating all partnerships for this topic is NASA Marshall Space Flight Center (MSFC)/Michoud Assembly Facility (MAF). Additional design, test, and analysis support

can be coordinated with Glenn Research Center (GRC)/Plum Brook Station and Goddard Space Flight Center (GSFC)/Wallops Flight Facility (WFF). NASA Center points of contacts can be found in Attachment 7.

4.3 Programmatic Considerations

There are no specific deviations from the main announcement details. Proposals should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0.

ATTACHMENT 5:

TECHNOLOGY TOPIC 5 – Small, Affordable, High Performance Liquid Propellant Rocket Engine Development

5.1 Description of Topic

Small affordable liquid propellant rocket engines are required across a wide spectrum of launch vehicles and concepts. In particular, central to the successful development of affordable suborbital reusable as well as small satellite (<180 kg) launch vehicles is the availability of highly affordable, high performance main propulsion systems. Additionally, new upper stages for larger launch vehicles require the development, certification and availability of entirely new low cost, high performance small rocket engines (<35,000 lbf, <155 kN thrust). The key to achieving breakthroughs in both markets is the ability to produce and operate their primary propulsion systems at a small fraction of the cost of traditional systems. Multiple commercial space ventures are vigorously pursuing efforts to fulfill these critical needs. However developing and sustaining the expertise and capabilities associated with the design, development, test, and evaluation (DDT&E) of such propulsion systems requires a substantial commitment of resources, especially for smaller companies. Opportunities exist to achieve affordable propulsion systems by employing new manufacturing technologies, leveraging COTS components where possible, and using novel propulsion system technologies and design approaches.

One approach to achieving affordability is the introduction of advanced manufacturing and integration techniques that could lead to reduced development time and lower recurring production costs. Rocket engine components such as combustion chambers, injector heads, propellant valves, nozzle bodies, and turbomachinery typically utilize special alloys and include a high number of intricate internal passages. Until recently fabricating such precision components required enormous time and expense using traditional machining and welding. Only after lengthy fabrication processes could an engine developer test the components to judge performance and iterate on any necessary design changes. However, additive manufacturing in combination with other advanced manufacturing techniques now enables major engine components to move from design to performance testing in weeks instead of months or years. NASA has gained significant experience in the use of additive manufacturing to create small rocket engine components. Working with commercial entities interested in developing their own small rocket engines, NASA can assist in developing and fabricating appropriate small rocket engine components.

Meanwhile, innovative engine cycles, propellant combinations, and rocket engine design ideas promise improvements in performance, operability, and reliability. In many cases commercial organizations are pursuing these new designs and concepts. NASA, with its deep expertise in rocket engine DDT&E, can provide US industrial interests with assistance and support in their rocket engine development plans.

Perhaps of highest interest to industry is access to NASA test facilities where rocket engine components as well as integrated engines can undergo both cold flow and hot

fire testing. Such test facilities are expensive to build, maintain, and operate and can thus add significant costs to the development cycle for a new rocket engine. NASA maintains a wide range of such engine test facilities that will substantially improve the business case for developing new engines via a partnership with industry.

Given the scope of the challenge and the importance of reduced launch cost to future national needs, small, affordable, high performance, liquid propellant rocket engine development is well suited for facilitated collaboration using the public-private partnership model. Target engines for this topic are in 35,000 lbf or lower thrust class and would find application on either a boost stage sub-orbital or small satellite launch vehicle, or the upper stage of a larger launch vehicle. Proposals of interest would leverage corporate investment with NASA provided test facilities, manufacturing capabilities, technical expertise, and other technical capabilities to undertake joint DDT&E of promising innovative propulsion systems in order to speed their readiness for use in commercially provided launch services. The proposed scope of work must conform to solicitation resource/timeline not-to-exceed (NTE) constraints as indicated in Section 2.1. Statements of work should also clearly define the tasks performed by the offeror as well as those performed by participating NASA partners.

NASA offered support may include but is not limited to:

- NASA personnel to assist in furthering the design, development, testing, and qualification of a propulsion system/component
- Access to and design support for NASA additive manufacturing capabilities
- Engineering assistance with analysis and technology development risk reduction efforts addressing design, manufacturing, performance, stability, thermal, material compatibility, scalability, and life concerns
- Propulsion system testing time in NASA facilities at conditions of interest to the application
- Assistance with sensors, diagnostics, instrumentation, and measurements for thruster characterization
- Labor resources necessary to execute the final assembly of the instrumented thrusters and carry out the technology performance evaluations
- Resources required to operate the data acquisition system and to store the acquired data for a NASA test facility
- Post-test analysis and expert evaluation of the acquired data for a NASA test facility

Contributions from prospective partners may include but are not limited to:

- Overall propulsion systems design and performance objectives
- Propulsion system/component hardware for performance evaluation
- Raw materials for additive manufacturing using NASA capabilities
- The expected performance characteristics of the propulsion system as they relate to potential applications of benefit to NASA’s future missions or other missions in the overall U.S aerospace enterprise
- Resources required for the partner to help plan and witness the technology evaluation including the partner’s labor and travel

5.2 Partnership Coordination

Offerors are required to partner with NASA Centers for support. The Lead Center is NASA Marshall Space Flight Center (MSFC)/Michoud Assembly Facility (MAF) and will coordinate all partnerships on this topic. Additional design, test, and analysis support can be coordinated with Glenn Research Center (GRC)/Plum Brook Station, Stennis Space Center (SSC), and Langley Research Center. NASA Center points of contacts can be found in Attachment 7.

5.3 Programmatic Considerations

There are no specific deviations from the main announcement details. Proposals should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0.

Attachment 6: Draft Space Act Agreement (SAA)

The following is a draft Non-reimbursable Space Act Agreement (SAA). This draft is provided as an example of the most likely content of an SAA between the parties. The final SAA entered into pursuant to this competition will be the subject of final negotiations between NASA and a participant. Questions or comments on the draft SAA may be submitted to the official point of contact listed in Section 2.1.

NONREIMBURSABLE SPACE ACT
AGREEMENT BETWEEN
THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND [*Name of Partner*]

ARTICLE 1. AUTHORITY AND PARTIES

In accordance with the National Aeronautics and Space Act (51 U.S.C. § 20113), this Agreement is entered into by the National Aeronautics and Space Administration (hereinafter referred to as "NASA") and [*Name of Partner*] located at [*Partner's Address*] (hereinafter referred to as "Partner" or *[insert Partner name or acronym, as appropriate]*). NASA and Partner may be individually referred to as a "Party" and collectively referred to as the "Parties.

ARTICLE 2. PURPOSE

[This section will broadly describe the purpose of the proposed partnership between NASA and the Partner. It will include a summary of the information included in the participant's Executive Summary as described in section 3.2 of this ACO. In addition to the purpose of the proposed partnership, this section will also broadly summarize the participant's capabilities and how the partnership aligns with NASA's Strategic Plan.]

ARTICLE 3. RESPONSIBILITIES

A. NASA will use reasonable efforts to:

[This section will incorporate the Government resources requested by participants for their capability development effort under this Space Act Agreement. This section will include Base Support and any Specific Support requested by the participant and agreed to by NASA. Section 2.7 of this ACO provides details to participants regarding access to Government provided resources. The proposed use of Government resources should track the participant-proposed milestones in Article 4 that the Government resources are utilized to support.]

B. Partner will use reasonable efforts to:

[This section will incorporate the resources provided by the participants toward their capability development effort under this Space Act Agreement. These responsibilities should track participant-proposed milestones in Article 4.]

ARTICLE 4. SCHEDULE AND MILESTONES

The planned major milestones for the activities defined in the "Responsibilities" Article are as follows:

[This section will incorporate the Participant proposed capability development and demonstration milestones. Each milestone shall include a descriptive title, objective success criteria, and planned achievement dates (month and year). Milestones should represent significant technical and business progress in the program. At least one milestone per calendar quarter is recommended.]

1.	[Identified capability development or demonstration milestone.]	[Planned achievement date for milestone.]
2.	[Identified capability development or demonstration milestone.]	[Planned achievement date for milestone.]
3.	[Identified capability development or demonstration milestone.]	[Planned achievement date for milestone.]

ARTICLE 5. FINANCIAL OBLIGATIONS

There will be no transfer of funds between the Parties under this Agreement and each Party will fund its own participation. All activities under or pursuant to this Agreement are subject to the availability of funds, and no provision of this Agreement shall be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, (31 U.S.C. § 1341).

ARTICLE 6. PRIORITY OF USE

Any schedule or milestone in this Agreement is estimated based upon the Parties' current understanding of the projected availability of NASA goods, services, facilities, or equipment. In the event that NASA's projected availability changes, Partner shall be given reasonable notice of that change, so that the schedule and milestones may be adjusted accordingly. The Parties agree that NASA's use of the goods, services, facilities, or equipment shall have priority over the use planned in this Agreement. Should a conflict arise, NASA in its sole discretion shall determine whether to exercise that priority. Likewise, should a conflict arise as between two or more non- NASA

Partners, NASA, in its sole discretion, shall determine the priority as between those Partners. This Agreement does not obligate NASA to seek alternative government property or services under the jurisdiction of NASA at other locations.

ARTICLE 7. NONEXCLUSIVITY

This Agreement is not exclusive; accordingly, NASA may enter into similar agreements for the same or similar purpose with other private or public entities.

ARTICLE 8. LIABILITY AND RISK OF LOSS

A. Partner hereby waives any claims against NASA, its employees, its related entities, (including, but not limited to, contractors and subcontractors at any tier, grantees, investigators, customers, users, and their contractors and subcontractors, at any tier) and employees of NASA's related entities for any injury to, or death of, Partner employees or the employees of Partner's related entities, or for damage to, or loss of, Partner's property or the property of its related entities arising from or related to activities conducted under this Agreement, whether such injury, death, damage, or loss arises through negligence or otherwise, except in the case of willful misconduct.

B. Partner further agrees to extend this unilateral waiver to its related entities by requiring them, by contract or otherwise, to waive all claims against NASA, its related entities, and employees of NASA and employees of NASA's related entities for injury, death, damage, or loss arising from or related to activities conducted under this Agreement.

ARTICLE 9. INTELLECTUAL PROPERTY RIGHTS - DATA RIGHTS

A. General

1. "Related Entity" as used in this Data Rights Article means a contractor, subcontractor, grantee, or other entity having a legal relationship with NASA or Partner that is assigned, tasked, or contracted to perform activities under this Agreement.
2. "Data" means recorded information, regardless of form, the media on which it is recorded, or the method of recording.
3. "Proprietary Data" means Data embodying trade secrets developed at private expense or commercial or financial information that is privileged or confidential, and that includes a restrictive notice, unless the Data is:
    a. known or available from other sources without restriction;
    b. known, possessed, or developed independently, and without reference to the Proprietary Data;
    c. made available by the owners to others without restriction; or
    d. required by law or court order to be disclosed.
4. Data exchanged under this Agreement is exchanged without

restriction except as otherwise provided herein.

5. Notwithstanding any restrictions provided in this Article, the Parties are not restricted in the use, disclosure, or reproduction of Data provided under this Agreement that meets one of the exceptions in 3., above. If a Party believes that any exceptions apply, it shall notify the other Party before any unrestricted use, disclosure, or reproduction of the Data.
6. The Parties will not exchange preexisting Proprietary Data under this Agreement unless authorized herein or in writing by the owner.
7. If the Parties exchange Data having a notice that the Receiving Party deems is ambiguous or unauthorized, the Receiving Party shall tell the Providing Party. If the notice indicates a restriction, the Receiving Party shall protect the Data under this Article unless otherwise directed in writing by the Providing Party.
8. The Data rights herein apply to the employees and Related Entities of Partner. Partner shall ensure that its employees and Related Entity employees know about and are bound by the obligations under this Article.
9. Disclaimer of Liability: NASA is not restricted in, or liable for, the use, disclosure, or reproduction of Data without a restrictive notice under paragraphs A.3., B. or H. of this Article or for Data Partner gives, or is required to give, the U.S. Government without restriction.
10. Partner may use the following or a similar restrictive notice under paragraphs A.3.,B, and H. of this Article.

Proprietary Data Notice
The data herein include Proprietary Data and are restricted under the Data Rights provisions of Space Act Agreement [*provide applicable identifying information*].

Partner should also mark each page containing Proprietary Data with the following or a similar legend: "**Proprietary Data – Use And Disclose Only Under the Notice on the Title or Cover Page**."

B. Data First Produced by Partner Under this Agreement

If Data first produced by Partner or its Related Entities under this Agreement is given to NASA, and the Data is Proprietary Data, and it includes a restrictive notice, NASA will use reasonable efforts to protect it. The Data will be disclosed and used (under suitable protective conditions) only for U.S. Government purposes.

C. Data First Produced by NASA Under this Agreement

If Partner requests that Data first produced by NASA or its Related Entities under this Agreement be protected, and NASA determines it would be Proprietary Data if obtained from Partner, NASA will mark it with a restrictive notice and use reasonable efforts to protect it for [*insert a period of up to five years, typically one or two years*] after its development. During this restricted period the Data may be disclosed and used (under suitable protective conditions) for U.S. Government purposes only, and

thereafter for any purpose. Partner must not disclose the Data without NASA's written approval during the restricted period. The restrictions placed on NASA do not apply to Data disclosing a NASA owned invention for which patent protection is being considered.

D. Publication of Results

The National Aeronautics and Space Act (51 U.S.C. § 20112) requires NASA to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. As such, NASA may publish unclassified and non-Proprietary Data resulting from work performed under this Agreement. The Parties will coordinate publication of results allowing a reasonable time to review and comment.

E. Data Disclosing an Invention

If the Parties exchange Data disclosing an invention for which patent protection is being considered, and the furnishing Party identifies the Data as such when providing it to the Receiving Party, the Receiving Party shall withhold it from public disclosure for a reasonable time (one (1) year unless otherwise agreed or the Data is restricted for a longer period herein).

F. Copyright

Data exchanged with a copyright notice and no indication of restriction under paragraphs A.3., B, C, or H of this Article (*i.e.*, Data has no restrictive notice) is presumed to be published. The following royalty-free licenses apply.

1. If indicated on the Data that it was produced outside of this Agreement, it may be reproduced, distributed, and used to prepare derivative works only for carrying out the Receiving Party's responsibilities under this Agreement.
2. Data without the indication of 1. is presumed to be first produced under this Agreement. Except as otherwise provided in paragraph E. of this Article, and in the *Invention and Patent Rights* Article of this Agreement for protection of reported inventions, the Data may be reproduced, distributed, and used to prepare derivative works for any purpose.

G. Data Subject to Export Control

Whether or not marked, technical data subject to the export laws and regulations of the United States provided to Partner under this Agreement must not be given to foreign persons or transmitted outside the United States without proper U.S. Government authorization.

H. Handling of Background, Third Party Proprietary, and Controlled Government Data

1. NASA or Partner (as Disclosing Party) may provide the other Party or its Related Entities (as Receiving Party):

a. Proprietary Data developed at Disclosing Party's expense outside of this Agreement (referred to as Background Data);

b. Proprietary Data of third parties that Disclosing Party has agreed to protect or is required to protect under the Trade Secrets Act (18 U.S.C. § 1905) (referred to as Third Party Proprietary Data); and

c. U.S. Government Data, including software and related Data, Disclosing Party intends to control (referred to as Controlled Government Data).

2. All Background, Third Party Proprietary and Controlled Government Data provided by Disclosing Party to Receiving Party shall be marked by Disclosing Party with a restrictive notice and protected by Receiving Party in accordance with this Article.

3. Disclosing Party provides the following Data to Receiving Party. The lists below may not be comprehensive, are subject to change, and do not supersede any restrictive notice on the Data.

a. Background Data:
[*Identify the Disclosing Party and insert specific listing of data items or, if none, insert "None."*]

b. Third Party Proprietary Data:
[*Identify the Disclosing Party and insert specific listing of data items or, if none, insert "None."*]

c. Controlled Government Data:
[*Identify the Disclosing Party and insert specific listing of data items or, if none, insert "None."*]

d. NASA software and related Data will be provided to Partner under a separate Software Usage Agreement (SUA). Partner shall use and protect the related Data in accordance with this Article. Unless the SUA authorizes retention, or Partner enters into a license under 37 C.F.R. Part 404, the related Data shall be disposed of as NASA directs:
[*Insert name and NASA Case # of the software; if none, insert "None."*]

4. For Data with a restrictive notice and Data identified in this Agreement, Receiving Party shall:

a. Use, disclose, or reproduce the Data only as necessary under this Agreement;

b. Safeguard the Data from unauthorized use and disclosure;

c. Allow access to the Data only to its employees and any Related Entity requiring access under this Agreement;

d. Except as otherwise indicated in 4.c., preclude disclosure outside Receiving Party's organization;

e. Notify its employees with access about their obligations under this Article and ensure their compliance, and notify any Related Entity with access about their obligations under this Article; and

f. Dispose of the Data as Disclosing Party directs.

I. Oral and visual information

If Partner discloses Proprietary Data orally or visually, NASA will have no duty to restrict, or liability for disclosure or use, unless Partner:

1. Orally informs NASA before initial disclosure that the Data is Proprietary Data, and
2. Reduces the Data to tangible form with a restrictive notice as required by paragraphs A.3., B, and H of this Article, and gives it to NASA within ten (10) calendar days after disclosure.

ARTICLE 10. INTELLECTUAL PROPERTY RIGHTS - INVENTION AND PATENT RIGHTS

A. General

1. NASA has determined that 51 U.S.C. § 20135(b) does not apply to this Agreement. Therefore, title to inventions made (conceived or first actually reduced to practice) under this Agreement remain with the respective inventing party(ies). No invention or patent rights are exchanged or granted under this Agreement, except as provided herein.
2. "Related Entity" as used in this Invention and Patent Rights Article means a contractor, subcontractor, grantee, or other entity having a legal relationship with NASA or Partner assigned, tasked, or contracted with to perform activities under this Agreement.
3. The invention and patent rights herein apply to employees and Related Entities of Partner. Partner shall ensure that its employees and Related Entity employees know about and are bound by the obligations under this Article.

B. NASA Inventions

NASA will use reasonable efforts to report inventions made under this Agreement by its employees. Upon request, NASA will use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, a negotiated license to any NASA invention made under this Agreement. This license is subject to paragraph E.1. of this Article.

C. NASA Related Entity Inventions

NASA will use reasonable efforts to report inventions made under this Agreement by its Related Entity employees, or jointly between NASA and Related Entity employees, where NASA has the right to acquire title. Upon request, NASA will use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, a negotiated license to any of these inventions where NASA has acquired title. This license is subject to paragraph E.2. of this Article.

D. Joint Inventions With Partner

The Parties will use reasonable efforts to report, and cooperate in obtaining patent protection on, inventions made jointly between NASA employees, Partner employees, and employees of either Party's Related Entities. Upon timely request, NASA may, at its sole discretion and subject to paragraph E. of this Article:

1. refrain from exercising its undivided interest inconsistently with Partner's commercial business; or
2. use reasonable efforts to grant Partner, under 37 C.F.R. Part 404, an exclusive or partially exclusive negotiated license.

E. Rights to be Reserved in Partner's License

Any license granted Partner under paragraphs B., C., or D. of this Article is subject to the following:

1. For inventions made solely or jointly by NASA employees, NASA reserves the irrevocable, royalty-free right of the U.S. Government to practice the invention or have it practiced on behalf of the United States or on behalf of any foreign government or international organization pursuant to any existing or future treaty or agreement with the United States.
2. For inventions made solely or jointly by employees of a NASA Related Entity, NASA reserves the rights in 1. above, and a revocable, nonexclusive, royalty-free license retained by the Related Entity under 14 C.F.R. § 1245.108 or 37 C.F.R. § 401.14 (e).

F. Protection of Reported Inventions

For inventions reported under this Article, the Receiving Party shall withhold all invention reports or disclosures from public access for a reasonable time (1 year unless otherwise agreed or unless restricted longer herein) to facilitate establishment of patent rights.

G. Patent Filing Responsibilities and Costs

1. The invention and patent rights herein apply to any patent application or patents covering an invention made under this Agreement. Each Party is responsible for its own costs of obtaining and maintaining patents covering sole inventions of its employees. The Parties may agree otherwise, upon the reporting of any invention (sole or joint) or in any license granted.
2. Partner shall include the following in patent applications for an invention made jointly between NASA employees, its Related Entity employees and Partner employees:

The invention described herein may be manufactured and used by or for the U.S. Government for U.S. Government purposes without the payment of royalties thereon or therefore.

ARTICLE 11. RELEASE OF GENERAL INFORMATION TO THE PUBLIC AND MEDIA

NASA or Partner may, consistent with Federal law and this Agreement, release general information regarding its own participation in this Agreement as desired.

ARTICLE 12. USE OF NASA NAME AND EMBLEMS

A. NASA Name and Initials

Partner shall not use "National Aeronautics and Space Administration" or "NASA" in a way that creates the impression that a product or service has the authorization, support, sponsorship, or endorsement of NASA, which does not, in fact, exist. Except for releases under the "Release of General Information to the Public and Media" Article, Partner must submit any proposed public use of the NASA name or initials (including press releases and all promotional and advertising use) to the NASA Associate Administrator for the Office of Communications or designee ("NASA Communications") for review and approval. Approval by NASA Office of Communications shall be based on applicable law and policy governing the use of the NASA name and initials.

B. NASA Emblems

Use of NASA emblems (i.e., NASA Seal, NASA Insignia, NASA logotype, NASA Program Identifiers, and the NASA Flag) is governed by 14 C.F.R. Part 1221. Partner must submit any proposed use of the emblems to NASA Communications for review and approval.

ARTICLE 13. DISCLAIMER OF WARRANTY

Goods, services, facilities, or equipment provided by NASA under this Agreement are provided "as is." NASA makes no express or implied warranty as to the condition of any such goods, services, facilities, or equipment, or as to the condition of any research or information generated under this Agreement, or as to any products made or developed under or as a result of this Agreement including as a result of the use of information generated hereunder, or as to the merchantability or fitness for a particular purpose of such research, information, or resulting product, or that the goods, services, facilities or equipment provided will accomplish the intended results or are safe for any purpose including the intended purpose, or that any of the above will not interfere with privately-owned rights of others. Neither the government nor its contractors shall be liable for special, consequential or incidental damages attributed to such equipment, facilities, technical information, or services provided under this Agreement or such research, information, or resulting products made or developed under or as a result of this Agreement.

ARTICLE 14. DISCLAIMER OF ENDORSEMENT

NASA does not endorse or sponsor any commercial product, service, or activity. NASA's participation in this Agreement or provision of goods, services, facilities or equipment under this Agreement does not constitute endorsement by NASA. Partner agrees that nothing in this Agreement will be construed to imply that NASA authorizes, supports, endorses, or sponsors any product or service of Partner resulting from activities conducted under this Agreement, regardless of the fact that such product or service may employ NASA-developed technology.

ARTICLE 15. COMPLIANCE WITH LAWS AND REGULATIONS

A. The Parties shall comply with all applicable laws and regulations including, but not limited to, safety; security; export control; environmental; and suspension and debarment laws and regulations. Access by a Partner to NASA facilities or property, or to a NASA Information Technology (IT) system or application, is contingent upon compliance with NASA security and safety policies and guidelines including, but not limited to, standards on badging, credentials, and facility and IT system/application access.

B. With respect to any export control requirements:

1. The Parties will comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 C.F.R. Parts 120 through 130, and the Export Administration Regulations (EAR), 15 C.F.R. Parts 730 through 799, in performing work under this Agreement or any Annex to this Agreement. In the absence of available license exemptions or exceptions, the Partner shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data and software, or for the provision of technical assistance.

2. The Partner shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of work under this Agreement or any Annex under this Agreement, including instances where the work is to be performed on-site at NASA and where the foreign person will have access to export-controlled technical data or software.

3. The Partner will be responsible for all regulatory record-keeping requirements associated with the use of licenses and license exemptions or exceptions.

4. The Partner will be responsible for ensuring that the provisions of this Article apply to its Related Entities.

C. With respect to suspension and debarment requirements:

1. The Partner hereby certifies, to the best of its knowledge and belief, that it has

complied, and shall comply, with 2 C.F.R. Part 180, Subpart C, as supplemented by 2 C.F.R. Part 1880, Subpart C.

2. The Partner shall include language and requirements equivalent to those set forth in subparagraph C.1., above, in any lower-tier covered transaction entered into under this Agreement.

ARTICLE 16. TERM OF AGREEMENT

This Agreement becomes effective upon the date of the last signature below ("Effective Date") and shall remain in effect until the completion of all obligations of both Parties hereto, or [*enter a term from one to five*] years from the Effective Date, whichever comes first.

ARTICLE 17. RIGHT TO TERMINATE

Either Party may unilaterally terminate this Agreement by providing thirty (30) calendar days written notice to the other Party.

ARTICLE 18. CONTINUING OBLIGATIONS

The rights and obligations of the Parties that, by their nature, would continue beyond the expiration or termination of this Agreement, e.g., "Liability and Risk of Loss" and "Intellectual Property Rights" related shall survive such expiration or termination of this Agreement.

ARTICLE 19. POINTS OF CONTACT

The following personnel are designated as the Points of Contact between the Parties in the performance of this Agreement.

Management Points of Contact:

NASA:	Partner:
Name	Name
Title	Title
Email	Email
Telephone	Telephone
Cell	Cell
Fax	Fax
Address	Address

Technical Points of Contact:

NASA:	Partner:
Name	Name

Title	Title
Email	Email
Telephone	Telephone
Cell	Cell
Fax	Fax
Address	Address

ARTICLE 20. DISPUTE RESOLUTION

Except as otherwise provided in the Article entitled "Priority of Use," the Article entitled "Intellectual Property Rights – Invention and Patent Rights" (for those activities governed by 37 C.F.R. Part 404), and those situations where a pre-existing statutory or regulatory system exists (e.g., under the Freedom of Information Act, 5 U.S.C. § 552), all disputes concerning questions of fact or law arising under this Agreement shall be referred by the claimant in writing to the appropriate person identified in this Agreement as the "Points of Contact." The persons identified as the "Points of Contact" for NASA and the Partner will consult and attempt to resolve all issues arising from the implementation of this Agreement. If they are unable to come to agreement on any issue, the dispute will be referred to the signatories to this Agreement, or their designees, for joint resolution. If the Parties remain unable to resolve the dispute, then the NASA signatory or that person's designee, as applicable, will issue a written decision that will be the final agency decision for the purpose of judicial review. Nothing in this Article limits or prevents either Party from pursuing any other right or remedy available by law upon the issuance of the final agency decision.

ARTICLE 21. MODIFICATIONS

Any modification to this Agreement shall be executed, in writing, and signed by an authorized representative of NASA and the Partner.

ARTICLE 22. ASSIGNMENT

Neither this Agreement nor any interest arising under it will be assigned by the Partner or NASA without the express written consent of the officials executing, or successors, or higher- level officials possessing original or delegated authority to execute this Agreement.

ARTICLE 23. APPLICABLE LAW

U.S. Federal law governs this Agreement for all purposes, including, but not limited to, determining the validity of the Agreement, the meaning of its provisions, and the rights, obligations and remedies of the Parties.

ARTICLE 24. INDEPENDENT RELATIONSHIP

This Agreement is not intended to constitute, create, give effect to or otherwise recognize a joint venture, partnership, or formal business organization, or agency agreement of any kind, and the rights and obligations of the Parties shall be only those expressly set forth herein.

ARTICLE 25. SIGNATORY AUTHORITY

The signatories to this Agreement covenant and warrant that they have authority to execute this Agreement. By signing below, the undersigned agrees to the above terms and conditions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	[PARTNER]
BY:_____	BY:_____
[TYPED NAME]	[TYPED NAME]
[TITLE]	[TITLE]
DATE:_____	DATE:_____

Appendix 1: Government Resources

1.1 Initial Point of Contact

See Attachment 7 below.

1.2 Available Collaboration Resources

The following resources (facilities, capabilities, expertise) may be available for collaboration, dependent upon the final selection of proposals:

- Aerodynamic Wind Tunnels
- Aerostructural (Thermal / Structural) Combined Full-Scale Loads Testing
- Analysis/Modeling (incl. Preliminary Mission and Architecture Design, Trajectory Analysis, Propulsion System Simulation and Analysis)
- Atmospheric Flight Planning
- Atmospheric Hybrid Thruster Testing
- Autonomous Flight Termination System (AFTS) Development
- Autonomous System Algorithm Design & Test
- Avionics, Instrumentation, & Systems Development
- Calibrated Launch & Recovery Range
- Calibrated Range / Restricted Airspace & Range Safety
- Combined Cycle Propulsion Testing
- Composite Structure Fabrication and Analysis
- Controlled Overfly Airspace for Rocket Firing
- Cryogenic Propellant Handling, Loading, Storage
- Design & Analysis for Payload Interface & Eject Mechanisms
- Electric Propulsion
- Energy Production, Management, Storage
- Entry Aero-Thermo Dynamic Analysis
- Entry Vehicle Thermal Protection System (TPS) Design
- Flight Operations (incl. Control Room Facilities, Hangars, Maintenance, Fabrication)
- Flight Vehicle Systems Integration (incl. Flight Critical Software Validation)
- Full-Scale Rocket Motor, Component, and Small Engine Test Facilities
- Guidance, Navigation, & Control (GNC) Hardware/Software
- Ground Support Systems & Expertise (incl. Specialized Handling for Hazardous Materials and Separation Systems)
- Hardware-in-Loop Engineering Simulation
- High Pressure Gas/Purge Systems
- Integrated Systems Health Monitoring
- Launch Vehicle Processing, Servicing, Launch, Recovery, Mission Monitoring

- LOX-LCH4 Engine Development
- Materials & Structures Design & Test (incl. Nanotechnology)
- Medical Analysis, Screening, Biomedical Laboratory, Radiation Monitoring
- Mission Planning and Optimization
- Modal/Vibration Testing
- Multi-Physics Modeling
- Nano-Launch Technology Development
- Nanosat/Smallsat Avionics & Systems testing
- Navigation Systems
- Nozzle Design/Analysis
- Numerous and Substantial Processing & Launch Facilities
- Onboard, Closed-Loop Algorithms for Guidance of RLV to Landing Site
- Oxygen/Hydrogen Materials Compatibility
- Parachute Reentry Systems
- Payload Processing, Integration, Test, Analysis, & Review
- Propellant & Other Hazardous Material Testing
- Propellant & Oxidizer Chemistry, LOX/LCH4
- Propellant Tank & Engine Module Testing
- Propulsion Component Testing & Evaluation
- Propulsion-Oriented Test Facilities (incl. Specialized Wind Tunnels)
- Range Safety: Tools, Techniques, and Products for Flight/Ground Systems [incl. Casualty Expectation (Ec) Calculations, Pyro/Separation Systems, and Autonomous Flight Safety System (AFSS)]
- Reentry Aerodynamics and Aerothermal Analysis
- Robotics
- Rocket Motor Testing (incl. Hot Fire Testing)
- Small Thruster Vacuum Test Facility
- Small- to Full-Scale UAV Operations (incl. Restricted Airspace)
- Software – Risk & Reliability Software Tool, Risk Analysis, Human Reliability Analysis
- Sounding Rocket Test Range for Rockets, Aircraft and Small Balloon Systems (Fixed & Mobile Worldwide Capability)
- Space Simulation Facilities
- Space Structures
- Specialized Fabrication
- Supercomputing (Modeling/Simulation/CFD)
- Thermal Protection Systems
- TPS Entry Systems & Materials Development & Testing
- Trajectory Simulation
- Trajectory Simulation
- Transonic/Supersonic Wind Tunnel (UPWT)
- UAV Autonomous Systems Development (incl. GNC)

- Vacuum Chambers
- Visible and Non-Visible Surveillance & High-Speed Engineering Imagery, Infrared Imagery Analysis, Plume Analysis

Appendix 2: Data Templates

Use of the following templates is required in order to facilitate a streamlined and equitable evaluation process.

2.1 Template 1: Proposed NASA Contributions

Complete Template 1 to identify any NASA services, facilities, equipment (loans), or software requested by Respondent. Provide a description of the proposed NASA contribution, an estimate of when the NASA resource is needed (round to the month), and rationale to demonstrate that it is not reasonably available on a commercial basis.

Template 1: Proposed NASA Contributions

Brief Description of Proposed Service, Facilities, Equipment, or Software	Timing of Need	Rationale to demonstrate that proposed NASA contribution is not reasonably available on a commercial basis
Ex. Thermal Vacuum Chamber – xx days	Oct – Dec 2016	[Rationale]
[Other Contribution]	[Other Date]	[Other Rationale]
[Other Contribution]	[Other Date]	[Other Rationale]

2.2 Template 2: Income Statement

Complete Template 2 to provide a year-by-year summary of anticipated revenues and expenses, consistent with the business plan.

Template 2: Income Statement

Fiscal Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Revenue						
Cost of Goods Sold						
Gross Profit						
Operating Expenses:						
Research & Development						

Sales, Marketing, & Business Development						
Other						
Total Operating Expenses						
Operating Income						

Appendix 3: Engagement Process

Prospective Participants are requested to follow this process to develop a collaboration strategy.

3.1 Proposal Development

Participants should develop the details of their proposal continuously during the engagement process, but prior to development of the Draft SAA. The Draft SAA should be the final product of the proposal development.

3.2 Initial Contact

Prospective Participants shall first communicate with the Center Point of Contact (POC) listed in Attachment 6 to discuss their collaboration needs.

3.3 Detailed Discussion of Collaboration Needs

The Participants will communicate with the designated POC to determine collaboration opportunities at a particular NASA installation. The POC may decide to provide additional points of contact that are more specific to the technology being developed or other support activity being requested. The Participants and NASA POCs will determine the resources and schedule that are needed to support the collaboration. The NASA POC will determine the level of Full-Time Equivalent (FTE) support and procurement funds required to support the collaboration.

3.4 Agreement to Collaborate

The POC will obtain a letter of certification signed by an official at the installation authorized to commit the requested resources, stating that the requested NASA contributions will be available in the timeframe required should the proposal be selected.

3.5 Development of draft Non-reimbursable Space Act Agreement

The Participants will jointly develop a draft SAA with the appropriate entities at the NASA installation with whom they wish to collaborate. The resources listed in the Draft SAA should conform to those listed in the Letter of Certification.

Attachment 7

NASA Center Points of Contact

Center	Name	Phone	Email Address
Ames Research Center	Harry Partridge	650.604.5236	harry.partridge@nasa.gov
Armstrong Flight Research Center	John F. Carter	661.276.2025	john.f.carter@nasa.gov
Glenn Research Center/ Plum Brook Station	Trudy F. Kortes	216.433.3632	trudy.f.kortes@nasa.gov
Goddard Space Flight Center/ Wallops Flight Facility	Peter M. Hughes Michael G. Hitch	301.286.2342 757.824.1522	peter.m.hughes@nasa.gov michael.g.hitch@nasa.gov
Jet Propulsion Laboratory	Ross M. Jones	818.354.7769	ross.m.jones@jpl.nasa.gov
Johnson Space Center/ White Sands Test Facility	Mark A. Dillard	281.244.8640	mark.a.dillard@nasa.gov
Kennedy Space Center	Robert L. Ashley	321.867.6037	robert.l.ashley@nasa.gov
Langley Research Center	David A. Dress	757.864.5126	david.a.dress@nasa.gov
Marshall Space Flight Center/ Michoud Assembly Facility	Stacy M. Counts	256.544.6004	stacy.m.counts@nasa.gov
Stennis Space Center	Robert C. Bruce	228.688.1646	robert.c.bruce@nasa.gov